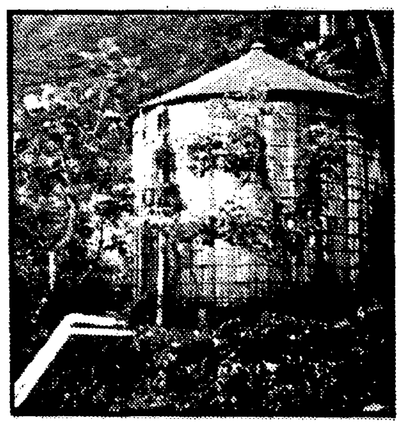
AMERICAN SAMOA WATER RESOURCES STUDY

ASSESSMENT OF WATER SYSTEMS AMERICAN SAMOA






U. S ARMY ENGINEER DISTRICT, HONOLULU

American Samoa · Coastal Zone Management Program

AMERICAN SAMOA WATER RESOURCES STUDY

ASSESSMENT OF WATER SYSTEMS
AMERICAN SAMOA

Prepared for:

U. S. Army Engineer District, Honolulu

September, 1978

Prepared by:

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September 19, 1978

Mr. Kisuk Cheung
Chief, Engineering Division
Department of the Army
U.S. Army Engineering Division
Building 230, Fort Shafter
Honolulu, Hawaii 96558

Dear Mr. Cheung:

Subject: Assessment of Water Systems
American Samoa
Contract DACW84-78-C-0008
URS 8504

We are pleased to submit this final report entitled "Assessment of Water Systems, American Samoa".

As directed by the scope of work this assessment contains documentation of all ongoing and proposed water system improvements; engineering evaluation and problem identification; and engineering and management recommendations for the problems identified.

The data resulting from this assessment and the recommendations made are intended to provide a source of information for all interested agencies.

We appreciated having had the opportunity to work on this challenging assignment.

Sincerely,

URS COMPANY HAWAII

Edward C. Stevenson

Edward C. Stevenson, P.E.
Vice President

ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

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CHAPTER I

INTRODUCTION

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INTRODUCTION

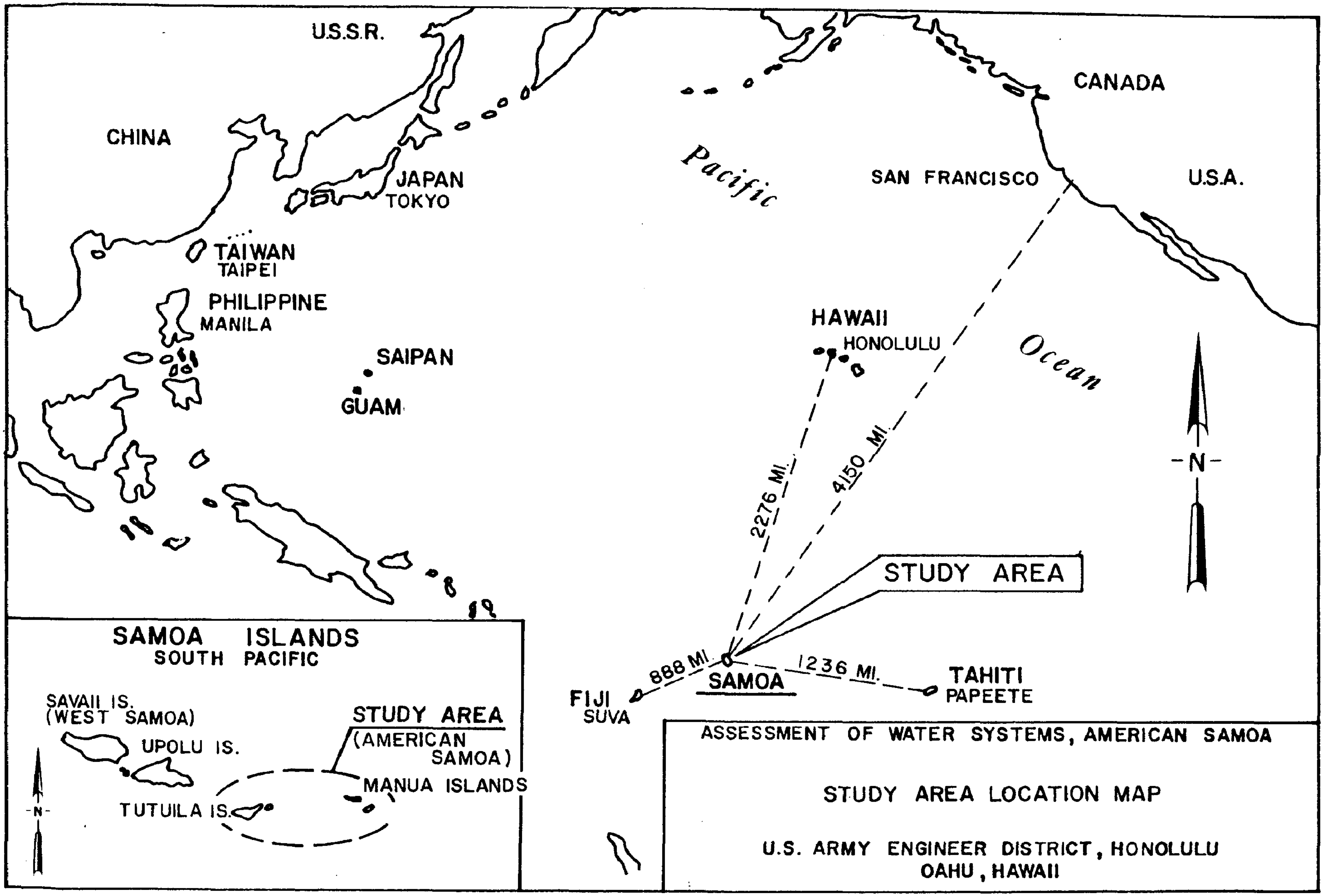
The water supply situation in American Samoa (Figure I-1) has been a constant source of problems and serious public and private concern from as early as 1960, when economic growth and expanding population began to put a strain on the capacity of the system. Since 1970, tens of millions of dollars have been spent on capital improvements to water systems with little or no apparent improvement to the quality of water service. The severity of this situation was particularly evident during the drought conditions of 1974, when strict water rationing forced restrictions on industrial consumption and resulted in serious economic impacts on the islands.

The water shortages seem unwarranted to residents and outsiders alike when considering that the islands receive up to 200 inches of annual rainfall and have a total population of only 30,000 people.

The general lack of communication and proper documentation has further complicated the situation with a great deal of public misunderstanding and misinformation regarding the objectives, priorities and progress of water system improvement programs.

While low rainfall have had a significant impact, an equally important factor has been the expanding population, economic growth and growing expectations for the quality of water service. A great deal has been accomplished in the past ten years in the areas of basal water production and delivery systems, and demands upon these systems have grown at an astounding rate.

As part of its American Samoa Water Resources Study, the U.S. Army Engineer District, Honolulu, in cooperation with the American Samoa



ASSESSMENT OF WATER SYSTEMS, AMERICAN SAMOA

STUDY AREA LOCATION MAP

U.S. ARMY ENGINEER DISTRICT, HONOLULU
OAHU, HAWAII

FIGURE I-1

Government (A.S.G.) has conducted this technical assessment of the water supply situation in the Territory of American Samoa.

The basic purpose of the Assessment of Water Systems, American Samoa, which was contracted to U R S Company Hawaii (Contract No. DACW84-78-C-0008), is to assist the Government of American Samoa in its water system improvement programs by documenting and evaluating these programs. This report will also serve as a source of information for all interested congressional, federal and local agencies. In effect, it will establish a "baseline" for the water supply situation in American Samoa.

STUDY OBJECTIVES

The specific objectives of this assessment are the following:

1. To document all ongoing and proposed water systems improvement programs.
2. To perform a detailed engineering evaluation of these programs and to identify specific problems.
3. To develop engineering and management recommendations in solution to the problems identified.
4. To prepare a report that will document and summarize the findings, conclusions and recommendations of this assessment.

SCOPE

The general scope of this assessment will consist of the following:

1. Basically, there are two types of water systems in use in the Territory of American Samoa: (a) the A.S.G. centralized system which serves a portion of the island of Tutuila and

(b) village water systems which serve the remainder of the territory. The scope of this study will include both types of water systems.

2. In evaluating improvement programs to determine their adequacy in meeting current and projected (year 2000) needs, this assessment will be based upon existing information and data.
3. The scope of this assessment will include the topics of source, transmission and arterial distribution, operation and maintenance, and management.

METHODOLOGY

The depth and detail of this study were restricted by the limited quantity and quality of basic water system operational data available. The A.S.G. Public Works Department, which is responsible for most data collection related to the water system, maintains meager records of the physical plant and its operating characteristics. The villages do not maintain any records pertaining to their water systems.

Most of the written data available on the water system is contained in reports and studies performed by various engineering consulting firms.

Additional field information was collected in Samoa during a two week field study in April of 1978. Existing reports, drawings, and correspondence were collected from the A.S.G. files; and interviews were held with A.S.G. officials responsible for the management design and operation of the water system. The existing water system shown in this report is as it existed on April 1, 1978.

It should be noted that the Department of Public Works was making substantial improvements to the system physical plant and the system management structure at the time of our field studies.

The recommendations pertaining to ground water development are based upon "Ground Water Development in American Samoa" prepared by the U.S. Army Engineer District, Honolulu (copy attached as Appendix B).

ACKNOWLEDGEMENTS

We wish to express our appreciation to the Governor's office, the Development Planning Office and the Department of Public Works for their assistance in preparation of this report.

During our field studies, it was our privilege to be in frequent contact with Mr. Edvin Remund, Director of Public Works, and Mr. Al Sundquist, Mr. Marty Heede, and Mr. Geoff Keeler of the Department of Public Works, Water Systems Division, who provided invaluable information and drawings on the existing water system and plans for future improvements. Our appreciation also goes out to Mr. Randy Morris, Mr. Abe Malae and Mr. Seti Maleah of the Water Sewer and Solid Waste Division for their cooperation and time in giving us insight into the operation of the water system.

We also received meaningful assistance from Mr. Joseph Pereira, Mr. James Pedersen and Mr. Alfonso (Pete) Galea'i of the Development Planning Office who provided us with direction for our studies and with data on the growth patterns of the study area.

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

Identification and Location

The study area includes the entire Territory of American Samoa except for Rose and Swains Island. American Samoa is the southernmost possession of the United States and consists of a group of seven islands located in the South Pacific at about 170° west longitude and 14° south latitude. These islands contain approximately 76.1 square miles and are about 2,300 nautical miles southwest of Hawaii, 1,200 nautical miles northwest of Tahiti, 1,600 miles northeast of New Zealand, and about 80 miles southeast of the independent state of Western Samoa, see Figure I-1. The islands of Samoa are located along the crest of a submarine volcanic ridge which extends for over 300 miles and trends generally 75° southeast.

The five volcanic islands of Tutuila, Aunu'u, Ofu, Olosega, and Ta'u are the major inhabited islands. Tutuila, the largest and principal island, is the center of government and business. Aunu'u, a satellite of Tutuila, lies one mile off the east coast of Tutuila. The three islands of Ofu, Olosega, and Ta'u are collectively called the Manu'a Islands, and lie some 65 miles to the east of Tutuila. The two remaining islands of American Samoa are Rose and Swains, both of which are coral atolls. Rose Island, about 160 miles to the east of Tutuila is the territory's only uninhabited island. It does not have enough water to support human life and is preserved as a wildlife refuge for sea turtles and birds.

Swains Island, about 230 miles north of Tutuila, is the northernmost island of the territory and is geographically a part of the Tokelau Islands, but administratively is part of American Samoa. The island is privately owned by the descendants of a New England whaling captain.

The islands of American Samoa were discovered in the 1700's by Dutch navigators. Although the islands remained unclaimed for many years they were the subject of great power struggles between the United States, Germany, and Great Britain. The Convention of 1899 resulted in the forfeiture of Germany and Great Britain of all claims east of the 171st meridian, and the United States dropped all claims to the islands of Upolu and Savai'i which now comprise Western Samoa. In 1900 the chiefs of Tutuila and Aunu'u ceded title to the United States. Four years later the chiefs of the Manu'a Islands followed suit. From 1900 to 1951 the U.S. Navy administered the islands as a territory of the United States. In 1951, administration was transferred to the U.S. Department of Interior. American Samoa remains an unorganized, unincorporated territory of the United States. Its inhabitants are American nationals (but not citizens) who may visit or emigrate to the United States without passports. No organic legislation has been enacted for the territory by the U.S. Congress. Since 1951, the governor of the territory has been appointed by the Secretary of the Interior. In November of 1977, however, following a recent plebiscite in which the citizens of American Samoa expressed a desire for more local control of their government, local elections were held for the positions of governor and lieutenant governor.

Topography

The islands of American Samoa are of volcanic origin and exhibit the rugged topographic relief common to Pacific volcanic islands. The islands rise precipitously from the ocean and their rugged flanks are clothed in lush tropical vegetation. Typically, sheltered embayments develop small coastal plains providing one of the few sources of flat land in the territory. Palm lined sand and coral rubble beaches rim much of the islands except where exposed to severe marine erosion. Beyond the narrow beach there is usually a moderately wide fringing reef providing limited protection to the shore. The maximum elevations for the five major volcanic islands are 2142, 280, 1621, 2095, and 3180 feet for Tutuila, Aunu'u, Ofu, Olosega, and Ta'u respectively. Drainage is provided by deeply incised stream valleys radiating from the summit of each distinct volcanic cone.

Tutuila is geologically the most complex of the islands. Its spine consists of overlapping centers of volcanic activity. The north shore is deeply indented by embayments with little flat land other than at the mouth of each of the streams. The coastline is typified by high cliffs plunging directly into the ocean. The southern coastline is slightly more protected. The Tafuna-Leone Plain extends along the south side of the island from Nuuuli westward to Leone. This formation is believed to be a late stage lava flow overlying a former barrier reef. During a lower sea stand, what is now Pago Pago Harbor was carved as a major stream valley. A rise in sea level flooded the former valley and produced one of the deepest and most sheltered harbors in the Pacific. The majority of the southern coast consists of broad fringing reefs except immediately near stream mouths where the salinity is too low for coral growth.

Tutuila Island is about 18 miles long and varies in width from 1 to 6 miles. The total land area is about 53 square miles. Land with slopes less than thirty degrees is scarce and found mostly in the Tafuna-Leone Plain. The Tafuna-Leone Plain has an area of about 13.5 square miles. The total land area with slopes less than thirty degrees is approximately 16.5 square miles or about 30 percent of the island.

Aunu'u, off the east coast of Tutuila, is a small volcanic tuff cone that is dominated by a slightly dissected crater whose rim rises 200 to 300 feet above sea level. Its land area is about 0.6

square mile. The floor of the crater is occupied by a marsh and lake. Marine erosion has developed steep cliffs on the east and south sides of the cone. Habitation on the island is on a low coastal flatland that rims the west and north sides of the island.

Ofu and Olosega are remnants of a single volcanic island and are separated by a 500 foot wide straight. Both islands rise abruptly from the ocean with little flat land other than a narrow band along the coast. A small island off the western side of Ofu has been spectacularly carved into grottos, caves, and arches by marine erosion. The land areas of Ofu and Olosega are approximately 3 and 2 square miles respectively.

Ta'u is the largest of the Manu'a Islands, covering 17 square miles. It is formed from the northern hemisphere of the shield volcano, Mt. Lata. Streams are scarce and have poorly developed and shallow valleys. The south side of the island is inaccessible and consists of spectacular cliffs and cascades that drop over 1000 feet into the sea. Most of the coastline along the northern and western sides of the island are fringed by a fairly wide coastal plain fronted by narrow beaches. The villages on the west end of the island are built on terraces which are 10 to 15 feet above sea level and are composed of sand dunes and storm benches of coral sediments deposited by high waves.

Climate

The climate of American Samoa is tropical and characterized by wet and dry seasons rather than the continental four seasons of winter, spring, summer, and fall. During the wet or summer period of November through April, the islands lie in the intertropical convergence zone. This results in weak and variable winds, high temperature, rainfall, and humidity. In the dry season or winter from May through October, the islands are influenced by the southern hemisphere trade winds. The prevailing southeasterly winds bring slightly lower temperatures and less rain.

Precipitation results from the upward deflection of the trades as they pass over the island as well as from major storm fronts and isolated thunderstorms. The annual precipitation varies with both location and elevation. The Pago Pago airport on the Tafune-Leone Plain receives an average of 125 inches per year, whereas the Pago Pago Harbor area only four and one-half miles away receives an average of nearly 200 inches per year. The summit of Mt. Alava which overlooks Pago Pago Harbor at an altitude of 1600 feet receives more than 250 inches per year. It would appear that American Samoa is blessed with an over abundance of rainfall. However, seasonal rainfall variations are considerable and it is not uncommon for extended dry periods of two to three months duration to result in critical water supply shortages. In general, the driest months are June through September and the wettest months are December through March.

The average temperature is about $80^{o}F$. The mean daily range is about $12^{o}F$ and the mean seasonal variation is only $3^{o}F$. January, February, and March are the warmest months, and June, July, and August are the coolest. The highest recorded temperature at the airport was in the low 90's and the lowest was near $60^{o}F$.

Flora and Fauna

The vegetation of American Samoa originally consisted of dense tropical forests. Man has influenced this by forest clearing for both cultivation and habitation. Approximately 70 percent of

Tutuila and 95 percent of Ta'u remain in original tropical forest vegetation. Cultivated lands consist principally of banana, taro, and coconut plantations. Breadfruit trees are also extensively grown.

American Samoa has few endemic animals. Domestic animals such as fowl, pigs, and dogs were brought in with the early polynesian settlers. There are no snakes but other small reptiles are plentiful. The most abundant forms of wildlife are birds. The number of species is limited to about thirty indigenous species and a dozen or so seasonal inhabitants.

There have been few studies of the freshwater biological communities since most of these streams are of intermittent flow. The reef communities fringing the islands are characterized by numerous species of fish such as surgeon fish, goat fish, parrot fish, wrasse, mullet, and damsel fish. The open ocean surrounding the territory contains skipjack and yellowfin tuna, marlin, sailfish, and dolphin.

SOCIO-ECONOMIC CHARACTERISTICS OF THE STUDY AREA

Culture

The people of American Samoa are culturally tied to the Western Samoans. The Samoan people are polynesians as are the Hawaiians, Tahitians, Tongans, and the Maoris of New Zealand. Their traditional lifestyle revolves around the extended family ("aiga"). The aiga is a communal lifestyle headed by a chief ("matai"). The matai is responsible for the welfare of all under his rule. Additionally, he is responsible for protection and distribution of the family's land.

The traditional Samoan lifestyle ("fa'a Samoa") is often at odds with traditional western lifestyles. Fa'a Samoa places great importance on the dignity and achievements of the group rather than on individual achievements.

Historically, each village which was composed of one or more aigas, was self supporting, and trade with other villages or outsiders was not a basic necessity of life. Increased contacts with western outsiders have caused the development of a job oriented cash economy. This cash economy is in conflict with fa'a Samoa and, increasingly, Samoans are faced with the conflicts between the desire for western material goods and a strong cultural link with fa'a Samoa. Traditional Samoan values and authority are being diffused by increased formation of nuclear families and values emphasizing individual achievement and opportunity. The result is that American Samoa is becoming increasingly westernized and fa'a Samoa is becoming more and more difficult to maintain. There is a bright spot in that the youths of American Samoa are becoming increasingly conscious and proud of their heritage. This program is being actively pursued through the educational system.

Economy

American Samoa's economy is dependent on a very limited base. Employment trends in American Samoa reflect the shift from a subsistence type of economy to a cash economy. Many Samoans prefer the cash-paying jobs available in the Pago Pago Harbor area, and particularly with the Government of American Samoa, the largest single employer in the territory. In 1970 the A.S.G. employed 2,790 persons or 54 percent of the total work force of 5,094. Since 1970 A.S.G. employment continued to increase while employment in private sector is believed to have increased only slightly.

Other leading employers are the food processing industries, including can manufacturing, the shipping and transportation industry which includes seafaring and dockside personnel, and tourism. The Starkist and Van Camp tuna canneries employed over 1,100 Samoans in 1970. Additionally, there were over 2,900 oriental fishermen employed by the fishing boats based out of Pago Pago. These fishermen undoubtedly spent a portion of their income while in port thus stimulating the entire economy. Unfortunately, the total number of fishing boats based out of Pago Pago has been declining.

Although much of the current work force is engaged in unskilled labor, an increasing number of Samoans are seeking higher education in professional fields and are gradually expected to assume jobs now held by non-Samoans ("palagi"). This is in consonance with the U.S. Department of Interior's goal to promote economic, social, and political development leading to a full measure of self-government and the active participation of the residents of American Samoa in the life of their country.

A drastic reduction of corporate income tax in FY 1975 was caused by a severe water shortage that resulted in a shutdown of the canneries. The lost tax income rippled throughout the territory as the A.S.G. was required to implement a reduction in force by 10 percent. Similar incidents of boom/bust economy are possible until a more diversified tax base can be established. The variability of Federal grants and loans also affects the level of A.S.G. employment.

CHAPTER II

SUMMARY

CHAPTER II

SUMMARY

GENERAL

The American Samoa Government Central Water System

Over the past eight years, considerable effort has been expended toward improvement of the American Samoa water supply situation. Upon performing this engineering review, it was evident that substantial improvements to the physical plant of the American Samoa Government (A.S.G.) water system have been achieved. The rapid improvement of the system has been accompanied by extensive expansion into new service areas in response to critical water shortages. While the extensions were made with the best of intentions, in some cases insufficient analysis was made of the ability of the existing system to adequately operate and supply these new areas. The water system was improved and extended faster than the ability to reliably manage and operate the new system. Consequently, complaints about the quality of water service continue in spite of the fact that the system is producing and distributing over five times as much water as it was during the dry season of 1972.

The management and operational problems have created a general public misunderstanding of the A.S.G. motives in development of the water system. Residents of areas with water shortages feel that water is being taken from their area to serve the industrial, commercial and governmental centers. There is an urgent need to develop a public information and education program to counteract the many public misconceptions.

For the existing service areas, improvements to the water production and transmission components of the central system have essentially been completed. The emphasis is now being directed toward upgrading the distribution system and more efficient system management and operation.

The Village Water Systems

Efforts to improve village water systems have also increased over the past eight years in response to a growing population and to greater per capita demands for water caused by rising standards of living. The improvements to village water systems have largely been made on an unplanned basis in the form of remedial improvements to the grossly inadequate existing water systems. Traditionally, the villages want to remain independent of outside influences and retain operational control over the water systems, but they lack the financial resources and technical abilities.

The A.S.G. is placed in a difficult position in the villages of trying to improve the standard of living and to maintain water service to the many government operated facilities (schools, offices, housing, etc.) without having operational control over the water system.

Past attempts to improve village water systems have been largely unsuccessful because the villages have not contributed to or participated in the planning and construction processes.

In cooperation with the Samoan community, the A.S.G. needs to establish a firm policy to clarify its role and functions when dealing with village water systems.

MANAGEMENT

A reorganization of the Department of Public Works functions dealing with water systems design, construction, maintenance, and operation to take advantage of existing professional talent and to improve coordination is needed. As a recommendation, a Water Division could be formed within the Department of Public Works, to combine planning, design, construction, operation, and maintenance of all water systems under one Assistant Director of Public Works. This organization would provide increased engineering expertise for operational decisions without duplicating engineering or support staff efforts in separate design and operation divisions. The existing in-service training program should be expanded to include all levels of management, as well as field personnel and the topics expanded to include billing and other management considerations.

Additional repair crews and equipment, meter installation and meter reading crews, mid-level managers, and engineering expertise will be required if the benefits of the new transmission and sources development programs are to be extended to the people and if the government is to operate and maintain planned improvements in the best long-term interest of the territory.

A future alternative for consideration is the formation of a separate authority such as a Board of Water Supply. The formation of a separate Water Division could serve as a first step. The Board would presumably have all of the functions of the previously mentioned Water Division and would operate more independently of the A.S.G. This would require development of separate billing, procurement, and other administrative functions creating additional overhead expense and a demand for trained manpower that is critically short in Samoa. The Water Board concept does not now appear warranted for the marginal benefits of bypassing political pressure and cumbersome governmental regulations regarding personnel and procurement procedures.

Long-term planning and policy direction from the highest level of territorial government also needs to be developed. Such items as the philosophy of continual subsidy of the water system or the possibility of system revenue meeting all (or a fixed percentage) of operating costs need to be addressed in the form of governmental policy. The goals of expansion of the system and of increased potable water quality also require attention.

An ongoing public awareness program should be incorporated into the Water Division activities. The program should include both formal public hearings and informal workshops, as well as regular television news coverage of system changes. Dissemination of information on how the system operates and the problems encountered by the Water Division would be of value. Announcing failures and successes in solving difficult problems will also do much to narrow the gap between public expectations and Water Division capabilities. This mutual understanding will do much to improve water system management, from which the people of the territory will ultimately benefit.

RIGHT-OF-WAY ACQUISITION

Right-of-way acquisition for water system improvements has been a serious problem for the Department of Public Works for many years. Badly needed projects have been delayed or halted indefinitely by extended right-of-way negotiations or right-of-way disputes. Projects have been modified at the increased cost or at the expense of the system's operating efficiency in attempts to skirt right-of-way problems.

The problems are related to the communal land ownership system under which the majority of the land in American Samoa is held. Most of the communal land has not been surveyed and registered with the court, and ownership and boundary disputes over this land often exist. There is no formal procedure to obtain a verification of land ownership when the land has not been recorded. Persons stating a claim on land, can file and often can obtain temporary restraining orders against A.S.G. land acquisition attempts without posting a bond.

The problems have also resulted from the use of relatively short term (two-year) contract employees, causing a lack of continuity and also from the lack of an effective training program for local personnel. The lack of continuity has resulted in an inconsistent policy toward right-of-way acquisitions.

Public meetings should be arranged in cooperation with the Office of Samoan Affairs before a final selection is made of the right-of-way route in the village or villages affected. The public meeting will help identify the landowners, problems with the selected route, and problems in obtaining land values and lease rentals in the area by the appraisers.

The Department of Public Works needs to staff the Right-of-Way Branch with trained personnel as required for efficient and prompt right-of-way acquisitions. Whenever necessary, long-term (e.g., five year) contracts of employment could be made with skilled personnel to maintain continuity in the Right-of-Way Branch.

The Office of the Territorial Registrar needs to adopt indexing systems that will increase the efficiency of retrieving land sale records, leases, easements, condemnation and right-of-way acquisitions.

Legislation to require the mandatory posting of a bond or surety to secure temporary restraining orders seeking to restrain right-of-way acquisitions is needed.

DISTRIBUTION SYSTEM

The distribution system is the weak link in the existing A.S.G. water system. Residential consumption rates averaging 285 gallons per capita per day have been estimated in the existing services. This high consumption is due primarily to leakage and waste in unmetered and illegal connections. Excess water consumption is a burden on the existing transmission, pumping, and storage facilities to the extent that the system has not operated correctly.

The existing distribution system consists of small diameter pipelines that branch off of the main transmission pipelines into the communities. Pipelines and meters are indiscriminately placed. The meters are difficult to locate, to read, and to repair; and it is sometimes nearly impossible to relate a specific meter to any given house.

Distribution pipelines wander throughout villages above and underground, and it is difficult to determine which lines are metered and which are not. Illegal connections are simple to make and hard to police. Repairs to pipelines are sometimes difficult as no rights-of-way exist for most distribution pipelines.

The A.S.G. has recently begun an extensive five to ten year program to completely rehabilitate the existing A.S.G. distribution system. To be successful, the program needs support from the Governor's office and the local legislature. Initially, the program may not be popular, because right-of-way will be required for the new distribution system and many residents who now receive free or low flat rate water service will be required to pay. Overcoming the initial public resistance will be the first problem faced by the program. A comprehensive public education and public information program is required. If the importance of the program is communicated and results in the form of improved water service are demonstrated, then subsequent efforts will be made easier.

The objectives of the rehabilitation program are as follows:

1. To reduce water waste and misuse
2. To facilitate water system maintenance and repair
3. To reduce operating costs
4. To provide better fire protection
5. To provide equitable water use charges to all water system customers

EXPANSION OF THE A.S.G. WATER SYSTEM

A workable policy toward expansion of the A.S.G. water system service area needs to be developed. Any proposed expansion should be proceeded by detailed studies that identify the increased demands that will be borne by the management, operational, and water supply resources of the existing system. These studies should also evaluate the ability of the existing system to meet these new demands and as required, recommend where improvements are necessary. No expansion should be attempted until the water system has the resources to provide reliable water service.

Any expansion into areas served by village systems must consider the desires of the residents of these areas and be consistent with the overall A.S.G. policy toward village water systems.

WATER SUPPLY DEVELOPMENT

Ground water is recommended for development as the primary source of potable water. The consistently high quality of ground water developable at a relatively low cost makes ground water the most desirable type of water source. A separate study of surface water resources (Dames & Moore, 1978) indicated that approximately 164 million gallons of storage would be required for each million gallons per day of regulated flow. A storage reservoir of this magnitude in Samoa would require a dam approximately 200 feet high. Preliminary estimates indicate that ground water resources of the Tafuna-Leone Plain are sufficient to supply the demands of an expanded A.S.G. water system through the year 2000. The development of this resource should be undertaken with care, however, to insure that it is not over-developed.

More specifically, the recommendations for the management and development of the ground water resources are as follows:

1. Avoid over-development of the basal freshwater lens in the Tafunafou area by directing ground water development programs to other areas.

2. Investigate the potential of the Malaeimi and Malaeloa valleys which appear to be promising areas as supplemental sources of ground water for the central A.S.G. system.

3. Conduct a ground reconnaissance survey of villages outside the existing government system to identify and inventory those which are eligible for further ground water exploration.

4. Institute a program to seal abandoned and unsealed drilled holes and wells and to assure that production and observation wells in use have adequate sanitary seals.

5. Select production well sites above, or upstream, of anticipated sources of contaminants, insofar as possible, to minimize the need for strict watershed management and conflicting land uses.

6. Coordinate waste collection and disposal (wastewater and solid waste) and land use practices and plans to assure protection of ground water supplies.

7. Maintain the qualified technical expertise required in the engineering, design, and construction of wells to fit the particular hydrology and geology of subsurface conditions encountered at each individual well site and to oversee the mechanical aspects of well drilling.

8. Develop a hydrologic budget for the island of Tutuila. A hydrologic, or water budget is a method of quantifying the four phases of the hydrologic cycle (i.e., precipitation, evaporation and transpiration, surface water and ground water) and their interactions for a given area. It is particularly useful in managing water supplies and in evaluating and forecasting the impacts of certain actions (e.g., dry spells, projected growth and demand, etc.) on each hydrologic component.

COLLECTION OF ADDITIONAL DATA AND ADDITIONAL STUDIES

The basis for recommendations of the specific improvement items contained in this report is, as of necessity, based upon estimates of water production capabilities and water consumption requirements available at the time of this writing. The water system management has in the past maintained insufficient field operational data on the system. In the future, more detailed information of flow rates, flow rate variations, and pressure distribution must be collected at all critical points in the system. These data should be periodically analyzed to determine the most efficient sizing and location of proposed improvements and the most efficient operational procedures.

As noted in Chapter I, the scope of this assessment is limited to documenting and evaluating all ongoing and currently proposed A.S.G. water systems improvement programs. Hence, the specific recommendations contained herein do not comprise a complete water plan for the territory.

In view of the fact that current water system improvements are only planned through 1981 and in light of the findings of this assessment, a long-range (e.g., 25- or 50-year) water plan to guide future development and to minimize the recurrence of past problems is highly recommended. In formulating this plan, such subjects as alternative methods for developing village water systems, the identification of area-by-area future water demands, alternative sources of water to meet future demands, and an investigation of federal requirements as they apply to villages and the A.S.G. system could be addressed. Coordinated improvements with economic development, waste disposal and other planning activities would also be part of the long-range water plan.

8. Develop a hydrologic budget for the island of Tutuila. A hydrologic, or water, budget is a method of quantifying the four phases of the hydrologic cycle (i.e., precipitation, evaporation and transpiration, surface water and ground water) and their interactions for a given area. It is particularly useful in managing water supplies and in evaluating and forecasting the impacts of certain actions (e.g., dry spells, projected growth and demand, etc.) on each hydrologic component. It requires extensive data collected through well-conceived monitoring programs over extended periods.

COLLECTION OF ADDITIONAL DATA AND ADDITIONAL STUDIES

Studies and plans are necessary for the orderly development of expanding facilities like water systems. These plans are, however, based upon data as of a given point in time and projections of future events. Future events cannot be predicted with certainty and the longer the projection, the less the certainty. Studies and plans, therefore, have a "shelf life" that is considerably shorter than the life of the facilities that they planned.

The basis for recommendation of the specific improvement items contained in this report is, as of necessity, based upon estimates of water production capabilities and water consumption requirements. The water system management has in the past maintained insufficient field operational data on the system. In the future, more detailed information of flow rates, flow rate variations, and pressure distribution must be collected at all critical points in the system. This data should be periodically analyzed to determine the most efficient sizing and location of proposed improvements and the most efficient operational procedures.

The existing planning for water system improvements is currently extended only through 1981. There is a need for long term planning that will guide future water system development. This planning should address itself to subjects such as identification and evaluation of alternate water sources, identification of area by area future water demands, investigation of alternate methods for developing village water systems, and an investigation of federal requirements as they relate to village and the A.S.G. system. The planning effort needs to set out a logical year to year development sequence for the future water system improvements.

CHAPTER III

THE EXISTING SYSTEM, ONGOING AND PROPOSED IMPROVEMENT PROGRAMS

CHAPTER III

THE EXISTING SYSTEM, ONGOING AND PROPOSED IMPROVEMENT PROGRAMS

HISTORICAL OVERVIEW OF SYSTEM

There is no evidence of any organized water systems in American Samoa prior to the first contacts with the outside western world. Water was evidently obtained directly from surface streams and springs. During times of drought, those villages and areas without perennial streams no doubt obtained drinking water from coconuts and used the ocean to bathe in.

The first organized community water system was probably constructed to serve the early United States coaling station near Fagatogo. A water service agreement recently discovered by the Department of Public Works shows an agreement between the U.S. Navy and Fagatogo Village dated August 23, 1899, and indicates one of the earliest attempts to obtain water rights to serve the Navy base.

Periodic expansion to the coaling station and World War II brought on the first significant attempts to develop and distribute water in American Samoa. During this period the Pago Pago well shaft was constructed and a 10-inch pipeline was laid to the ship repair yard (at the present site of the tuna canneries and marine railway), a stream intake was constructed on Vaipito Stream above Pago Pago Village and a pipeline extended to the vicinity of Happy Valley, the Upper Fagaalu Dam was constructed together with a hydroelectric power generation plant at Fagatogo, a stream intake was constructed on Vaitele Stream to supply water to the airfield at Tafuna, a stream intake was constructed on Leafu Stream to serve the airfield at Leone, and several other miscellaneous improvements were made to the water systems of villages (Tula, Pago Pago, Aua, Nuuuli and Amanave) that had military personnel stationed in them.

From the end of World War II until 1960, very little, if anything was done to improve the water supply systems of American Samoa. When the U. S. Department of Interior took responsibility for administration of the Territory in 1950, the Territorial Government (A.S.G.) assumed responsibility from the Navy for operation and maintenance of the water systems. The primary emphasis was on those systems that served governmental facilities. By the villagers own choice and by governmental policy not to interfere, the villages maintained control over village systems that served the local population.

Beginning in the early 1960's, American Samoa began its rapid transition from a villages subsistence economy to a cash economy. During this period, the Tafuna International Airport was constructed, the roadway connecting each end of the island to Pago Pago along the south shore was completed and the tuna canneries offered the first major opportunity for employment outside of government service. These improvements brought about changing life styles and together with an expanding population (from 6,000 in 1900 to nearly 30,000 in 1974) brought water shortages and demands for a more reliable water service.

In response to these demands, the A.S.G. had the first master plan for the water system prepared. This report (Austin, Smith & Associates, 1963) noted the increasing population and water needs in American Samoa and recommended that improvements be made to the old Navy system.

The 1963 report identified the inability of the existing surface water systems to meet peak demands and recommended the construction of nearly seven million gallons of distribution storage reservoirs, the construction of various 6-inch and 8-inch diameter transmission pipelines and the construction and further investigation of ground water sources. Based upon this 1963 report, the A.S.G. designed and built the following improvements: (See Figure III-1 for general locations)

1. The 6-inch pipeline from Atuu to Leloaloa
2. The 1.0 million gallon reservoir at Pago Pago
3. The 2.25 million gallon reservoir (stilling basin) and filters at Vaipito Stream
4. The 8-inch pipeline from Pago Pago to Happy Valley
5. The Pago Stream well (since abandoned)
6. The Fagatogo booster pumps and pressure filters
7. The 1.0 million gallon reservoir at Fagatogo (Maugaalii Reservoir)
8. The 1.0 million gallon reservoir at Blunts Point
9. The 4.5 million gallon reservoir at (Virgin Falls) Fagaalu
10. The lower Fagaalu Stream intake and pressure filters
11. The 8-inch distribution pipeline from Fagaalu to Utulei
12. The Papa Stream well (since abandoned)
13. The 6-inch distribution pipeline from the Papa Stream well to the Tafuna A.S.G. housing area

These improvements were limited to areas containing A.S.G. facilities and in which the A.S.G. had some control over right-of-way. Villages along the systems were allowed to connect to the systems if they desired.

After 1964, the water systems were not improved to any extent until approximately 1970. In 1970, there was a cooperative attempt between the A.S.G. and the villages to improve the old Navy system in the Leone area. The improvement was of limited success, however, because it was not fully completed. Pipeline and storage reservoirs were constructed in the villages of Leone, Malaeloa, Puapua, Taputimu and Vailoatai.

The surface water supplies had inadequate quantity in the dry season and insufficient pressure head to serve all the villages. The villages attempted to operate the system on their own, but intervillage disagreements, the lack of technical and managerial expertise, and limited water supplies prevented the system from being operated correctly.

In 1970, the A.S.G. also began construction of the Lago Puna water system. This system ran from its source at Puna Stream through Mapusagafou, Pavaiai, Faleniu, Futiga, Iliili and Vaitogi villages. The operation of this system proved less than satisfactory, however, because the sole source for the system (Puna Stream) had inadequate supply during the dry season. The later addition of wells at Iliili has helped the situation, but lack of back up facilities and operational problems have created continued water shortages.

The FY 1971 Water System Expansion Program was in three separate locations on Tutuila Island. In the Western District it was planned to improve and extend the Leone Water System as far west as Atauloma. Unfortunately, because of insufficient funds, it was only possible to construct the system from Asili westward to Atauloma. (See Figure III-3)

In the eastern district, a pipeline from Auto to Alofau was planned to be constructed. However, the system was only extended from Auto to the east as far as Pagai due to insufficient funds and village disagreements. (See Figure III-4)

In the Bay Area (Pago Pago), the A.S. G. water system was extended from Leloaloa to the Aua Village School. Insufficient funds also prevented the construction of the proposed tanks along this pipeline.

Low rainfalls in the first half of the 1970's coupled with accelerating population and economic growth brought increased attention to the A.S.G.'s water system planning. In 1972, an updated water system master plan (Austin, Smith and Associates, 1972) was prepared for the Pago Pago, Tafuna and Leone areas.

The water system improvement program for 1973 and 1974 followed the recommendations of the 1972 system master plan. New wells were completed at Tafunafou, a 12-inch pipeline was constructed from Nuuuli to Fagaalu Village and two booster stations at Nuuuli and Fagaalu were provided to connect the well field with the Bay Area. As part of the industrial park project, a 12-inch pipeline was constructed to connect the Tafunafou well field with the water system. These programs interconnected the various portions of the A.S.G. water systems into one water system.

Because of continuing problems with quality and quantity of the existing surface water sources, an analysis of the capabilities of the water system to operate solely on ground water was prepared (R.M. Towill Corp., 1975). The FY 1975 Water System Improvement Program was originally designed in accordance with the criteria in this report which assumed that all water used in the Bay Area would be transported from the Tafuna Plains area.

Before the design was completed, a separate proposal was made to utilize the Olovalu Crater to store large quantities of surface water and to transport the water into the Bay Area via a high pressure gravity system that used large diameter pipelines and no intermediate booster pump stations (CH2M-Hill, 1975). The A.S.G. decided that the construction costs under this Crater Proposal were excessive when compared to ground water development and that ground water should be developed to its maximum first. However, the Olovalu Crater proposal was never formally adopted or rejected. Apparently the pipeline sizes in the 1976 system were somewhat affected by the Crater Proposal on the chance that the proposal may be adopted at a later date. There is no documented evidence, but the size increases are very similar to those recommended in the Olovalu Crater project.

The Olovalu Crater has subsequently been used as a borrow site for cinders to such an extent that the crater rim is now breached. The earthwork necessary to repair the breach make the economics of this project even less desirable.

The FY 1975 improvement program consisted of pipeline improvements along the main highway from Tafuna to Nuuuli, from Fagaalu to Utulei and from Leloaloa across Pago Pago Park to Siufuga. The FY 1976 and 1977 programs continued the improvements to the transmission capabilities between the Tafuna well field and the canneries and provided additional distribution storage.

The FY 1976 and FY 1977 capital improvements program contained the following transmission and storage projects:

1. Pipelines between Mapusaga and Tafuna (16 and 20-inch diameter)
2. Pipelines between Siufuga and Atuu (12-inch diameter)
3. Pipelines between the Airport and Iliili (16-inch diameter)
4. Pipelines between the Industrial Park and the Airport (16-inch diameter)
5. Pipelines at Fagaalu Park (20-inch diameter)
6. Water storage tank at Mapusagafou (0.50 million gallons)
7. Water storage tank at Pavaiai (0.75 million gallons)
8. Water storage tank at Aua (1.0 million gallons)

EXISTING AMERICAN SAMOA GOVERNMENT WATER SYSTEM

General

The existing A.S.G. water system extends from Aua Village in the east to Futiga Village in the west (Figure III-1). The A.S.G. water system is distinguished from village water systems in that it is operated and maintained by the Department of Public Works and it is recognized by the residents as A.S.G. owned. Generally customers receiving water from the A.S.G. system are charged a fee, either flat rate or by metered consumption. In contrast, village systems are theoretically owned and operated by the villages and generally do not charge for water service.

Within this area serviced by the A.S.G. water system and in all other villages, there are also numerous private individual family or village water systems. Residences are frequently connected into one of these private systems as well as the A.S.G. system, and residents utilize the free water service in the private system when adequate supplies are available.

The A.S.G. has an unofficial interest in the operation of many of the outside village water systems that attempt to maintain water service to the A.S.G. facilities within villages (Table III-1). In these systems, the A.S.G. does not provide an active maintenance role, but responds to requests for assistance when water service fails. These requests often become demands, since necessary facilities such as schools, offices, and similar A.S.G. facilities are forced to shut down when water becomes unattainable.

The A.S.G. participated in or completely paid for construction of some of the water facilities in Asili, Leone and Fagaitua, but does not

TABLE III-1

INVENTORY OF AMERICAN SAMOA GOVERNMENT FACILITIES IN VILLAGES

VILLAGE	DESCRIPTION OF FACILITIES	REMARKS
Poloa, Nua	Elementary school	Served by village water system
Atauloma	Employee housing	
Leone	Dispensary, offices, fire station, elementary school, high school, experimental farm, employee housing	
Iliili, Pavaiai, Aoloaufou	Elementary schools	Served by American Samoa Government water system
Mapusaga	Community college, employee housing	
Tafuna	Elementary school, airport, power station, construction offices and equipment, industrial park, offices, employee housing	
Fagaalu	Hospital, elementary school, employee housing	
Utulei	Housing, offices, high school, elementary school, T.V. studio	
Fagatogo	Housing and offices	
Pago Pago	Offices, elementary school	
Satala	Power station, marine railway	
Aua	Elementary school	
Fagasa, Vatia, Lauliituai	Elementary schools	Served by village water system
Fagaitua	High school, post office, employee housing	
Alofau	Elementary school	
Amouli	Dispensary	
Tula, Aoa, Masefau	Elementary schools	
Aunuu	Elementary school, dispensary	
Ofu, Olosega, Faleasao	Elementary schools, dispensaries, power stations	Manua Islands water system
Luma	High school	
Fitiuta	Elementary school	

actively operate or maintain them except in Leone where a minor A.S.G. center has developed. The A.S.G. has drilled and maintains several wells in the Leone area to provide water to the A.S.G. facilities and in the process, supplies most of the water to the system.

Sources

The existing A.S.G. water supply system is supplied by both surface and ground water sources. The older Navy water system relied almost entirely on surface water supplies. Since the early 1970s, the A.S.G. has relied more heavily on ground water. The existing surface water supplies with estimates of the average flow rates and minimum observed flow rates are shown in Table III-2. Only the Fagaalu intake water is metered; the other figures shown are estimated.

Ground water supplies are now the major sources of water for the A.S.G. system, primarily from drilled wells in the Malaeloa, Iliili and Tafunafou areas of the Western District. The current major production wells are shown on Figure 1 and in Table 3 of Appendix B. Smaller quantities of ground water are obtained from a shallow dug well in Utulei and a dug shaft with a collection gallery in Pago Pago Valley.

Treatment

The treatment of ground water is limited to simple chlorination at the Tafunafou well field and the Utulei dug well. All other wells are untreated.

The surface water sources from Vaitele, lower Fagaalu and upper Fagaalu intakes have pressure filters and chlorination. The Vaipito intake has gravity filtration through three valveless gravity filters and

TABLE III-2

EXISTING AMERICAN SAMOA GOVERNMENT SURFACE WATER SOURCES

SOURCE	Estimated [1] Average Flow (GPM)	Estimated [2] Minimum Dry Season Flow (GPM)
Fagaalu Intake	220	0
Puna Dam	50	0
Vaitele Intake	300	50
Upper Fagaalu Reservoir	250	100
Vaipito Intake (Utumoa)	220	100
Malaeloa Intake	150	50
Leone Intake	200	100
	1390	400

[1] Estimated flows, no meters except for Fagaalu intake.

[2] Based upon reported observations during the 1971 and 1974 dry seasons.

chlorination. The Puna intake has only chlorination facilities; the Malaeloa and Leone intake waters receive no treatment.

Generally, all of the existing treatment equipment is inadequate and unreliable for the treatment of potable water.

Service Levels

Because of ground elevation differences within the A.S.G. water system, the system is broken into four service areas (See Figure III-1). The highest service area contains the village of Mapusagafou and runs from elevation 390 to 590. Water supplies for this area are obtained from the Puna intake.

The next lowest service area contains the villages of Futiga, Iliili and part of Pavaiai. Water supplies for this area are obtained from the drilled wells at Iliili. The village of Vaitogi is fed by water dropped from Iliili through a pressure reducing valve.

The villages of Mapusaga, Faleniu and part of Pavaiai are fed from wells number 67 and 69 at Malaeimi and the new Mapusaga (ASCC) booster station which lifts water from the Tafunafou well field.

The bulk of the area from Tafuna to Aua is in the lowest service level and is fed from the Tafunafou well field and the surface water sources.

The upper portions of Pago Pago and Fagatogo villages are served from the stream sources in the respective valleys.

EXISTING VILLAGE SYSTEMS

General

There is no evidence of any village water system improvements in American Samoa prior to 1900. The water needs of early Samoa were normally met at streams, springs, or along the ocean shore. In times of extreme drought, the ocean was used for bathing and the coconut provided liquid for drinking.

During the 50 years of Navy administration, it was the policy to stay out of local affairs and consequently, little development of village resources resulted during this administration.

Outside of the Bay Area, the earliest water systems were constructed during World War II. Evidence of these systems can be seen in Tula, Amuuli, Aua, Nuuuli, Leone, and Amanave villages. Each of these villages had some sort of an American military base or personnel stationed in them, and the water systems are a result of their presence.

Up until the 1960's, these village water systems were the most advanced form of water systems outside of the Bay Area. By the 1960's, most of the villages had made some improvements, but they were normally on an individual family basis and were not village-wide. The improvements normally consisted of development of springs and streams with small diameter pipelines (under two inches) for water delivery. No provision for water treatment and little or no water storage capacity were provided.

For most of the village communities located outside of the A.S.G. water system, the most common water system developments are small reservoirs or catchments formed by concrete dams built across streams. Occasionally, a few families developed a hillside spring for their own use.

The storage capacity of the catchments are small (100 to 10,000 gallons). Many villages also have 5000 to 30,000 gallon concrete or wooden tanks for storage outside of the catchment. Water is piped directly from the catchment or reservoir to the consumer's tap using small (1/2 to 6-inch) diameter galvanized iron or plastic pipes.

In most villages, there are several separate water systems belonging to several individual families within the village. These systems have sometimes been interconnected and form complex systems within the village.

Current Situation

There is little or no mapping of village water systems. For the most part, the systems have evolved bit by bit over the years without any planning. Partial information on the sources and layout of existing village water systems is available in R.H. Dale's Inventory of Village Water Systems in American Samoa, 1970 and Inventory of the Economic Development Administration Village Water System Program, 1975 by URS/ The Ken R. White Company.

Just a decade ago, it was common for each village to have only a few outdoor outlets, consisting of 3/4-inch pipe risers four to six feet high and bent at the top to direct water downward. The fortunate families had one or even two of these outlets to themselves. All washing and bathing was done at these pipe risers.

Within the past few years, the situation has changed completely. In addition to the existing pipe risers, many of the homes (now predominantly Western style), have some form of indoor plumbing. Some of the village families still use the outdoor risers and basins for washing clothes or for bathing. Privies are found in the outlying villages, but have been replaced in many areas by the high water consuming flush toilets.

Contamination of water supplies is still a serious threat to the village water systems. During heavy rainstorms, stream catchments and reservoirs are subject to high silt and debris loads. The steep slopes within the watersheds are cultivated by villagers and often foraged by pigs. The watersheds do not contain any industry within their boundaries, but because of limited land area, dwellings are beginning to encroach on the watersheds. The lack of water treatment in the village systems compounds the contamination problem.

Beginning in the 1960's, the A.S.G. began taking more interest in village water systems due to construction of schools, dispensaries or other A.S.G. operated facilities in many of the villages. To provide water to these facilities, the A.S.G. improved existing facilities or constructed new water systems with minimal capacity. These systems became a part of the village systems, and they soon were used by the village as well as the schools and dispensaries.

In 1970, a combination of an extremely low rainfall, increased population and increased standards of village living focused the first real attention on village water systems. This attention resulted in the A.S.G. securing a grant for improvements to village water systems from the Economic Development Administration. The A.S.G. has since applied for an additional grant from the Economic Development Administration.

EXISTING DESIGN CRITERIA

The design criteria used in past A.S.G. water system master plans and subsequent A.S.G. facilities design are summarized in Table III-3. With the exception of the 1963 report, the criteria used to determine water demands and the calculated water demands are fairly consistent and have comparable results. Direct comparisons of the various criteria can not be made as each is based upon different assumptions for the future of the system.

The 1963 report was prepared at the very beginning of American Samoa's unprecedented economic growth and population expansion and did not anticipate the rapid growth of the 1960-1978 era. During the decade 1950 to 1960, the population of American Samoa grew less than 1% per year. In 1963, it would have been very difficult to foresee what has happened in Samoa over the past fifteen years. At that time there was very little or no past supportive data to work with concerning the operating characteristics of the water system or population projections. Each succeeding report had the advantage of additional background data.

The proposed A.S.G. water system has expanded from a system that served only A.S.G. facilities to one that will serve most of the population on the south shore of Tutuila Island. Before the advent of the recent Safe Drinking Water Act, it would have been difficult to foresee the A.S.G. becoming involved in village water systems to the extent that it is today. The criteria is constantly changing; more and more areas are being served with higher quality water on a more consistent basis each year.

The existing surface water sources have become less important to the system over the years. The economic considerations concerning providing improved treatment facilities for these sources to obtain a consistently

TABLE III-3

COMPARISON OF PAST DESIGN CRITERIA

Report	Design daily per capita res. cons.	Allowance for indus. (MGD)	Design Service Area	Design Population Projections and Design[2] Peak Flow Rates (MGD) 1970	1980	1990	2000	2010	Comments
Austin-Smith Assoc., 1963	180	0.252	Tafuna to Leloaloa	7,500 (1.9)	8,800 (2.25)	10,000 (2.5)	11,500 (2.8)	12,500 (3.2)	Prepared at the very beginning of Samoa's unprecedented population and economic growth
Austin-Smith Assoc., 1972	150	1.650	Leone to Breakers Pt.		27,000 (5.6)	37,000 (7.8)	46,000		Noted drastic population increase and continued water waste. Recommended development of ground water transmission to Bay Area
R.M. Towill 1975	150	2.124	Tafuna to Breakers Pt.		12,730 (5.7)	16,413 (6.9)			Noted water wastage, pipe size based upon all sources outside Bay Area
CH2M-Hill 1975	200	2.16	Amanave to Breakers Pt.					49,200 (12.0)	Pipe size based upon all sources outside of Bay Area
Flanagan[1] 1976	180	1.2	Most of South Shore			36,900 (7.6)		48,200 (9.9)	No backup data to relate criteria to facilities design

1 See Table I-4 for breakdown.

2 Populations and peak flow rates are not directly comparable between reports due to different service areas.

TABLE III-4

EXISTING WATER SYSTEM DESIGN CRITERIA

Area	Population			Average Day Water Demand (Mgd)		
	1974	1990	2010	1974	1990	2010
West of Leone	1844	2200	2600	(0.33)	(0.40)	(0.47)
Leone System	3633	5250	7200	(0.65)	(0.95)	(1.30)
Logo Puna System	3861	5499	7600	0.70	0.97	1.37
Tafuna - Nuuuli - Matuu	3738	5200	7000	0.67	0.94	1.26
Fagaalu - Fagatogo	3665	4750	6050	0.66	0.85	1.09
Pago Pago - Aua	6070	7850	10,000	1.09	1.41	1.80
Existing canneries	--	--	--	0.70	0.75	0.80
Allowance for new industry	--	--	--	--	0.25	0.40
Eastern district	4515	6100	7700	(0.81)	1.10	1.37
TOTAL	27,326	36,849	48,150	5.61	7.62	9.86
Not in present service area				(1.79)		
Net water demand				3.82		

Source: American Samoa's Water System Improvement Program, Matthew J. Flanagan, 1976 high quality water has become less and less desirable. Reevaluation based upon availability, quality and cost-effectiveness of water sources has dictated that more and more water be obtained from ground water wells outside of the Bay Area, and this has increased the required size and extent of the transmission mains needed to move water from the well field to the Bay Area.

ONGOING AND PROPOSED A.S.G. WATER SYSTEM IMPROVEMENTS

The proposed water system capital improvement program for 1977 to 1981, as prepared by the A.S.G. is listed in Table III-5 and illustrated on Figures III-3, III-4, and III-5. Project item numbers are keyed to Figures III-3, III-4, and III-5 for convenience in listing them. The status of each project is listed as of April 1978. A brief item by item discussion of this program is as follows:

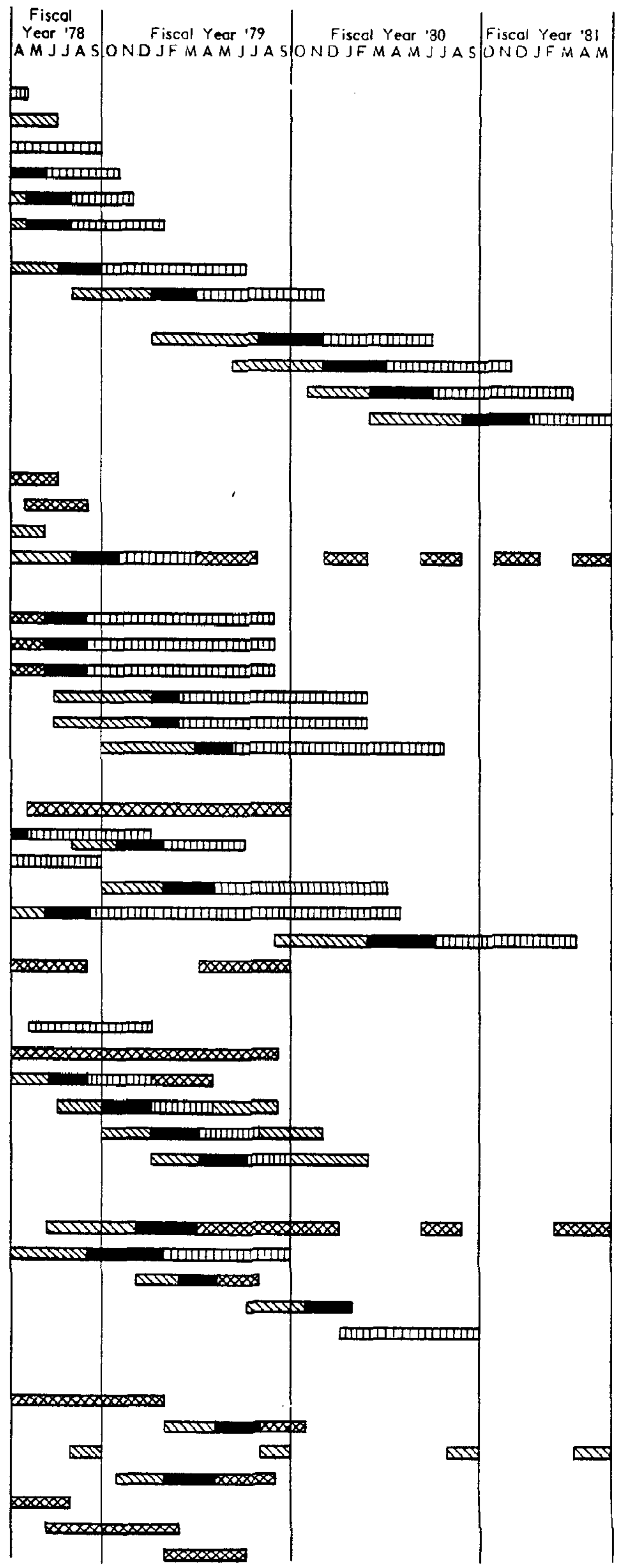
Item No. 1. Tafuna and Mapusaga Pipelines: These pipelines run along the main highway from the village of Mapusaga to the airport road turnoff and down the access road to the Tafunafou well field. The project is under construction and is scheduled to be completed by June, 1978. The pipeline is 16-inches in diameter along the road to the well field and along the highway toward Mapusaga. The pipeline is 20-inches in diameter along the main highway east of the airport road turnoff.

Along the main highway, the new pipeline is interconnected with the existing 8-inch pipeline and provisions have been made for installation of a booster pump station (see item 13) near the American Samoa Community College (A.S.C.C.). The future booster station will be used for lifting water up to the second service level to provide water for the villages of Mapusaga and Faleniu.

TABLE III-5

PROPOSED A.S.G. CAPITAL IMPROVEMENT PROGRAM

Item No.	Project Name	Project No.	Fiscal Year
	PIPELINES		
1	TAFUNA/MAPUSAGA 20" & 16"	760074	76
2	WELL #10 ASCC 12"	760082	76
3	IND. PARK/FAA/ILIILI	760603	76
4	ATUU TO LELOALOA	770495	76
5	AIRPORT FEEDER	780106	76
6	PAGO TANK ROAD/SIUFAGA 12"	780114	76
7	WESTERN LOOP 12"	770230 770339	76
8	MAPUSAGA/ALOAUFOU 8"	780098	76
9	AUMA/AMANAVE 8"	780155 780189	77
10	UTULEI TO MARKET 20"	780395	78
11	MARKET TO MALALOA 16"	790xxx	79
12	AUA/AUTO 8"	790xxx	79
	BOOSTER STATION		
13	MAPUSAGA (ASCC)	760090	76
14	PAVAIAI BOOSTER PUMP	770172	77
15	MAPUSAGAFOU BOOSTER PUMP	770412	76
16	FIVE PLACES	780387	78
	RESERVOIRS		
17	PAVAIAI .75 MG	770255	77
18	MAPUSAGAFOU .5 MG	770420	77
19	AUA 1.0 MG	770487	76
20	LEONE 3.0 MG	760504	76
21	FUTIGA .75 MG	800xxx	80
22	ASILI	780225	77
	WELLS & PUMPS		
23	EXPLORATORY/TEST	770602	77
24	FY-76 HUD PROGRAM	760025	76
25	FY-77 DOI PROGRAM	780197	77
26	FY-77 HUD PROGRAM	770404	77
27	FY-78 PUMPS	780346	78
28	FY-79	790xxx	79
29	SPARE PUMPS	770446	77
	REHABILITATION		
30	EXISTING RESERVOIRS (4)	760496	76
31	EXISTING FILTERS (10)	770594	76
32	FAGATOGO VILLAGE	760538	76
33	UTULEI VILLAGE	780130	76
34	PAGO PAGO VILLAGE	780148	76
35	NUUULI VILLAGE	780122	76
	TREATMENT		
36	WATER PURIFICATION	760520	76
37	CHLORINATOR CONVERSION	780213	77
38	RECHLORINATION	780221	77
39	FACILITIES	780xxx	78
40	TREATMENT FACILITIES	790xxx	79
	MISCELLANEOUS		
41	LEAK DETECTION	770321	76
42	MALAEIMI PIPELINE	770171	76
43	O&M MANUALS	770586	76
44	METER PROGRAM	780205	77
45	MISC. IMPROVEMENT FY-77	780247	77
46	MISC. IMPROVEMENT FY-78	780xxx	78
47	MISC. IMPROVEMENT FY-79	790xxx	79



DESIGN, IN-HOUSE
DESIGN BY A/E
BID & AWARD
CONSTRUCTION, FORCE ACCOUNT
CONSTRUCTION, CONTRACT

Source: Department of Public Works
American Samoa Government

Item No. 2. Well #10 to A.S.C.C.: This 12-inch pipeline will run from the far western end of the Tafunafou well field (well #10), northerly to the main highway near the American Samoa Community College (A.S.C.C.). The pipeline provides an alternate looped system route for water supply to the system should the well field pipeline fail. The pipeline is scheduled for design in fiscal year 1978. However, right-of-way problems are not solved and the funds may be reprogrammed.

Item No. 3. Industrial Park/FAA/Iliili: This project consists of a 16-inch diameter pipeline that extends along the Iliili to Airport Road from Lupelele School in Iliili village to the FAA road near the airport. The pipeline is under construction and is over 50% complete. When completed the pipeline will provide water to a large area of the Tafuna Plain that is presently undeveloped.

Item No. 4. Atuu to Leloaloa: This project is a 12-inch diameter pipeline that extends along the north side of the harbor from Atuu Village to Leloaloa Village. Construction bids for this project were scheduled to be opened on May 26, 1978. The pipeline will replace an existing 6-inch diameter pipe to provide better water service to the north side of the Bay.

Item No. 5. Airport Feeder: This project consists of an 8-inch diameter pipeline that will provide water service to the airport from the new industrial Park/FAA/Iliili pipeline. The project design is nearly complete and construction is scheduled for late in the fiscal year 1978. The pipeline will replace the old, troublesome World War II 6-inch airport service line.

Item No. 6. Pago Tank Road to Siufaga: This 12-inch pipeline will extend along the main highway from Pago Pago Village to near the Korea House at Siufaga Village. The project design is nearly complete and construction is scheduled to begin in August of 1978. The pipeline will complete the loop around Pago Pago Park and allow abandonment of the old 10-inch main that was constructed on the ground surface in the 1940's.

Item No. 7. Western Loop: This project will consist of an 8-inch and 12-inch pipeline loop and connection to the existing government water system at Futiga. The pipelines will serve the villages in the Leone area. The project is scheduled to be under design in July of 1978 and construction is scheduled to start near the end of 1978. The pipeline will provide water service to the villages of Pua Pua, Malaeloa, Taputimu, Leone and Vailoatai.

Item No. 8. Mapusaga to Aoloaufou: This project will consist of an 8-inch pipeline that will extend the A.S.G. system from the village of Mapusagafou to the village of Aoloaufou. Design is scheduled to begin in July 1978. The project will provide water service to the rapidly growing area above Mapusagafou.

Item No. 9. Auma to Amanave: This 8-inch pipeline project will extend the A.S.G. water system from Leone Village to the western tip of the island at Amanave Village. Design is scheduled to begin in January of 1979, and the project is projected to be completed in 1980.

Item No. 10. Utulei to Market: This proposed 20-inch pipeline will extend from Utulei Village to the market at Fagatogo Village. When completed, this segment will eliminate the use of the salt water fire system as a fresh water transmission pipeline. The pipeline is scheduled for construction in early 1980.

Item No. 11. Market to Malaloa: As the project title suggests, this project will consist of a 16-inch diameter pipeline that will extend from the market in Fagatogo Village to Malaloa Village. The pipeline is scheduled for construction in mid 1980.

Item No. 12. Aua to Auto: This project is an 8-inch diameter pipeline that will extend the A.S.G. water system from Aua Village east to the village of Auto. The pipeline is scheduled for construction in early 1981.

Item No. 13. Mapusaga (A.S.C.C.): This project consists of a booster station that will be connected to the Tafuna and Mapusaga pipeline (Item 1). The pump station will provide the capability of lifting water from the lower service level to the second service level villages of Mapusaga and Faleniu. The station is currently under construction and is scheduled for completion in 1978.

Item No. 14. Pavaiai Booster Pump: This booster pump will be used to lift water from the existing Mapusaga service level to the next highest service level. Villages within the higher water service level include Pavaiai and Futiga. When the transmission pipelines are complete, this booster will allow ground water from the Tafuna Plains to be distributed to the eastern end of the island. The station will also provide a backup supply for the existing Iliili ground water sources. Construction plans for this system are complete and construction is scheduled to start in the near future.

Item No. 15. Mapusagafou Booster Pump: This booster pump will be used to lift water from the third water service level to the fourth to serve Mapusagafou Village. The station will provide a backup supply of ground water to Mapusagafou which is currently served from the undependable Puna Stream intake.

Item No. 16. Five Places: These five booster stations will be installed near:

A. Lupelele School in Iliili Village to lift water from the lower service level to the second service level to provide water to the village of Iliili.
B. Puapua Village to lift water from the second service level to the third service level. The pump station will allow water from the Leone system to be moved easterly to Futiga.
C. Tafananai Village to move water from the Bay Area easterly to the villages along the south coast.
D. Mapusagafou (two stations) to lift water from the fourth service level to a fifth and sixth so that water can be provided to Aoloaufou Village.

Construction of these booster stations will span throughout the period of the proposed improvement program. The first station is scheduled for construction in early 1979.

Item No. 17. Pavaiai Reservoir: This proposed 0.75 million gallon storage reservoir will be located with a base elevation of 320 feet. The reservoir will serve the second service elevation villages of Faleniu and Mapusaga. The reservoir will be fed primarily by the Mapusaga (A.S.C.C.) booster station (Item 13). Construction began on the tank base in April, 1978.

Item No. 18. Mapusagafou Reservoir: This proposed 0.5 million gallon reservoir will be located with a base elevation of 635 feet. The reservoir serves the fourth service level village of Mapusagafou. The reservoir will be fed by the Mapusagafou booster pump (Item 15). Construction is scheduled to start on this reservoir during 1978.

Item No. 19. Aua Reservoir: This proposed 1.0 million gallon reservoir will be located with a base elevation of 175 feet. The reservoir will serve the area from the canneries to Aua Village. Construction is scheduled to start on this reservoir in late 1978.

Item No. 20. Leone Reservoir: The storage reservoir proposed for the Leone area is 3.0 million gallons in capacity. The reservoir will provide water to the proposed western loop water system. The reservoir will be supplied by wells near Malaeloa. Design of the project is scheduled to begin in July of 1978, with construction to be completed before March, 1980.

Item No. 21. Futiga Reservoir: The proposed 0.75 million gallon reservoir at Futiga will be set at base elevation of approximately 450 feet to serve the third service level. The villages in the third service level are Futiga and Pavaiai. The reservoir can be fed from the Puapua, Iliili or Pavaiai booster stations. Construction of this reservoir is scheduled to be begin in March of 1979.

Item No. 22. Asili Reservoir: The proposed 1.0 million gallon storage reservoir will serve the villages on the western end of the island from Leone to Amanave. Construction is scheduled for completion in 1980.

Item No. 23 Exploratory and Test Wells: This drilling program is to be accomplished by the A.S.G. operating the drilling rig obtained from the U.S. Army Corps of Engineers. The project was delayed for some time pending the recruitment of a qualified drill rig operator. The A.S.G. has solved this problem and the program is under way. Preliminary plans call for drilling in Malaeimi Valley, the Manu'a Islands and in the outer villages of Tutuila Island.

Item No. 24. Fy 76 HUD Program: This is an ongoing production well drilling program. Drilling under the first contract has been completed and the second contract for four additional wells was awarded in May of 1978. The third contract will be advertised upon completion of the second contract. The new wells under the second contract are scheduled to be drilled in the Tafuna well field somewhere between existing wells 60 and 52, one quarter of the way up the well field access road between wells 46 and 72 and at the Iliili Village church site and at Malaeloa Village.

Item No. 25. FY 77 DOI Program: This contract is for the procurement and installation of pumps for completed wells.

Item No. 26. FY 77 HUD Program: This program is for the drilling of additional production wells. Locations have not been determined.

Item No. 27. FY 78 Pumps: This program calls for the procurement and installation of pumps in existing drilled wells. Also included is a program to inventory and rehabilitate existing wells for more efficient operation of the existing facilities.

Item No. 28. FY 79: This is a proposed future drilling program for production wells. Locations have not been determined.

Item No. 29 Spare Pumps: This provides for procurement of spare pumping equipment for backup of existing equipment.

Item No. 30. Existing Reservoirs: This project consists of complete rehabilitation of the existing steel reservoirs at Pago Pago, Utulei, Blunts Point and Nuuuli. Work to be included is complete tank painting and repairs to the automatic level control valves. Construction is scheduled to start in late 1978.

Item No. 31. Existing Filters: This rehabilitation program calls for painting, recharging and repairs to the existing filters at Vaipito, Fagatogo, Fagaalu and Vaitele. Work is currently in process at the Fagatogo filters.

Item No. 32. Fagatogo Village: This project calls for improvements to the distribution and fire protection system in Fagatogo Village. The existing system consists of a multitude of small diameter pipelines that run throughout the village.

Item No. 33. Utulei Village: This project consists of design and construction of a pipeline loop through the upper part of Utulei Village. The new loop will provide improved water distribution and fire protection. Preliminary designs have been prepared for this project. Construction is scheduled to start in 1979.

Item No. 34. Pago Pago Village: Improvements are planned to the fire protection and water distribution of Pago Pago under this project. Preliminary routing has been determined and construction is scheduled for 1979.

CHAPTER IV

RECOMMENDED DESIGN CRITERIA

CHAPTER IV
RECOMMENDED DESIGN CRITERIA

POPULATION PROJECTIONS

General

Master plans for capital improvements with relatively long life require long-term population projections so that maximum benefits can be obtained from the improvements. The preparation of a long-term population projection for American Samoa is a very difficult and somewhat risky task. Population changes are closely tied to the economic conditions in Samoa and the United States and to the paternalistic inclinations of the U.S. Congress. During times of economic slowdown and/or reduced federal appropriations, history has shown that emigration from Samoa to the U.S. mainland and Hawaii has increased dramatically (American Samoans are American Nationals and are free to enter the U.S. at any time). During times of economic growth, emigration decreases and migrations to Samoa from other Pacific nations (most notably Western Samoa) increases.

Historical Background

The first record of the population of American Samoa was made by the U.S. Navy in 1900. Since then, the population has grown from 5679 to 30,600 in 1977. This represents an annual growth rate of 2.7% and a five-fold increase (Table IV-1).

From 1900 until the 1940's, the population grew at an annual rate of approximately 2%. Improved health conditions, better hygienic and sanitary habits, and the establishment of a hospital by the Navy contributed to this growth rate.

TABLE IV-1

POPULATION OF AMERICAN SAMOA FROM 1900 to 1974 BY DISTRICT

Census Date	Total	Eastern Tutuila	Western Tutuila	Manu'a	Swain's Island	Index (1900=100)	Annual % Chg. Since Prev. Census
June 1, 1900	5679	2221	1702	1756		100	
1901	5563	2342	1618	1603		98	-2.0
1903	5888	2441	1752	1695		104	2.8
1908	6780	3018	1907	1855		119	2.8
1912	7251	3186	2268	1797		128	1.3
Jan. 1, 1920	8058	3777	2408	1873		142	1.3
1926	8763	4221	2396	2060	87[1]	154	1.4
Apr. 1, 1930	10055	5032	2777	2147	99	177	3.4
Apr. 1, 1940	12908	6733	3431	2597	147	227	2.5
1945	16493	9338	4610	2406	139	290	4.9
Apr. 1, 1950	18937	10624	5330	2819	164	333	2.8
Sept.25, 1956	20154	11405	5902	2767	80	355	1.0
Apr. 1, 1960	20051	11137	6113	2095	106	353	-0.1
Apr. 1, 1970	27159	15955	9018	2112	74	478	3.0
Sept.26, 1974	29190	16828	10520	1808	34	514	1.6
Jan. 31, 1977	30600					538	2.1

[1] Swain's Island became an American possession in 1923.

Source: U.S. Navy, A.S.G and Federal censuses.

The 4.9% annual increase in population between 1940 and 1945 is attributed to a natural increase and to immigrants from Western Samoa who came to American Samoa because of a great demand for labor during World War II.

After the Navy left American Samoa in 1950, population growth was less than 1% and there was even a slight decrease in the period 1956 to 1960. This slowing of growth is most likely the result of mass emigration due to the economic slowdown after the war and neglect by the U.S. government.

The increased interest of the U.S. government in American Samoa beginning in the 1960's sparked a dramatic 3% annual growth in population between 1960 and 1970.

The census of 1974 indicated that the growth rate had slowed considerably between 1970 and 1974 to a rate of 1.53% per year. This is almost certainly due to increased emigration as the 1974 census coincided with an economic crisis and reductions in local A.S.G. employment in Samoa. The A.S.G. employs 10% of the population which, given the median age of 15, means that the A.S.G. employs the majority of the adult work force; thus, any reduction in A.S.G. employment has a severe economic effect.

A special sample census performed by the A.S.G. in January of 1977 indicates that the annual growth rate has increased to a current rate of approximately 2.1% between 1974 and 1977. The average annual rate between 1970 and 1977 was approximately 1.7%.

The American Samoa General Plan Interim Report and Preliminary General Plan, Phase II (Eckbo, Dean, Austin & Williams, 1972 and 1973) presented four alternate population projections at five year intervals through 1990 (Table IV-2). These projections were based upon studies and projections of fertility rates, employment and migration in American Samoa.

TABLE IV-2

AMERICAN SAMOA GENERAL PLAN POPULATION PROJECTIONS

Alternative	Actual 1970	1975	1980	1985	1990	1970-1990
			Numbers			
Projection I [1]	27,160	31,500	34,600	39,400	43,400	
Projection II [2]	27,160	30,500	34,000	37,000	40,500	
Projection III [3]	27,160	30,720	34,120	37,280	40,410	
Projection IV [4]	27,160	30,200	33,500	35,500	37,500	
			Annual Percent Increase			
Projection I		3.0	1.9	2.6	2.0	2.37
Projection II		2.4	2.2	1.7	1.8	2.02
Projection III		2.5	2.1	1.8	1.6	2.01
Projection IV		2.1	2.1	1.2	1.1	1.62

1. Projection I: Assumes trend fertility rates & planned employment.
2. Projection II: Assumes trend fertility rates & trend employment.
3. Projection III: Assumes planned fertility rates & planned employment.
4. Projection IV: Assumes planned fertility rates & trend employment.
5. Trend fertility rate - the present (1970) slightly decreasing rate projected based on no change in present (1973) government family planning program.
6. Planned fertility rate - the gradually decreasing rate projected in the Interim General Plan Report.

Source: American Samoa General Plan - Interim Report, 1972.

The high Projection I assumes current trend fertility rates and planned employment opportunities resulting in a 2.37% overall annual rate of population increase. Projection II assumes trend fertility rates and trend employment resulting in a 2.02% overall annual rate of population increase. Projection III assumes planned fertility rates and planned employment for a 2.01% overall annual rate of population increase. The low Projection IV assumes planned fertility rates and trend employment for a 1.6% overall annual rate of population increase.

Population Projection

For the purposes of water systems planning, the A.S.G. Development Planning Office has recommended a straight line projection of a 2% annual growth rate for the overall territory population.

For purposes of evaluating the proposed A.S.G. central water system, the study area of this report will be the entire south shore of Tutuila Island from Tula Village on the east to Amanave Village on the west.

The individual areas or zones will be as follows:

- Pago Pago Bay Area
- Tafuna Plains Area
- Tutuila Island West of Futiga Village
- Tutuila Island East of Aua Village

Factors which were considered in defining these zones include natural land systems (such as watershed divisions, topographic and elevational changes) and exposure or orientation identity. Also considered were man-made boundaries such as structures, linkages, and service systems. Consideration of the relative proximity to urbanizing areas or areas that have potential for urbanization was also one of the defining factors. The annual growth rates applied to each area have also been recommended by the A.S.G. Development Planning Office.

The Bay Area (Pago Pago) is anticipated to have a growth rate of 1.9%. The Bay Area represents the most significant social, political and economic gathering place in the territory; it is also the most congested and crowded. Suitable land for residential construction is becoming more and more scarce and will tend to restrict growth in the area.

The Tafuna Plains area has a total of over 3400 acres of land with a slope of under 30% and represents the largest area with potential for growth. This potential for growth has already begun to be realized as the population center of the island has gradually shifted westward out of the Bay Area since 1960. The percentage of total population has steadily increased in the Western district at the expense of the Eastern and Manua districts.

Growth in the Tafuna Plain area is assumed to follow the established trend for the Western district since 1960 and grow at an annual rate of 3.8%.

Tutuila Island west of Futiga Village is expected to increase in population at a rate nearly equal to that of the overall territory. The proximity of this area to the Tafuna Plain will promote expansion and an annual rate of 2.4% was used.

Tutuila Island east of Aua Village is expected to grow at a rate of only 0.75%. The lower rate for this area is in accordance with recent trends. The area has limited land area with slopes suitable for building construction and is the most remote from the business and commercial centers.

ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

TABLE IV-3

STUDY AREA POPULATION BY VILLAGE

	Population 1974	Population 2000
Tutuila Island West of Futiga (Annual Growth Rate 2.4%)		
Amanave	292	541
Failolo	80	148
Agugulu	55	102
Utumea	46	85
Seetaga	211	391
Nua	155	287
Afao	101	187
Asili	184	341
Amaluia	188	348
Subtotal	1312	2430
Vailoatai	742	1375
Taputimu	396	733
Malaeloa	295	546
Leone	1823	3377
Subtotal	3256	6031
Pago Pago Harbor Area (Annual Growth Rate 1.9%)		
Faganeanea	172	281
Matuu	238	388
Fatumafuti	72	117
Subtotal	482	786
Fagaalu	940	1533
Utulei	937	1529
Fagatogo	1788	2917
Subtotal	3665	5979
Pago Pago	2529	4126
Anua	41	67
Atuu	582	949
Leloaloa	429	700
Aua	1200	1958
Subtotal	4781	7800
TOTAL		14,565

	Population 1974	Population 2000
Tafuna Plains Area (Annual Growth Rate 3.8%)		
Futiga	273	720
Pavaiai	853	2249
Masepa	340	897
Subtotal	1466	3866
Iliili	615	1622
Faleniu	566	1493
Malaeimi	340	897
Subtotal	1521	4012
Mapusagafou	533	1406
Subtotal	533	1406
Aoloaufou	276	728
Aasufou	134	353
Subtotal	410	1081
Vaitogi	613	1617
Tafuna	820	2162
Nuuuli	2096	5527
Subtotal	3529	9306
TOTAL		25,702
Tutuila Island East of Aua Village (Annual Growth Rate 0.75%)		
Tafanainai	36	44
Lauliifou	170	206
Lauliituai	328	398
Aumi	123	149
Alega	23	28
Avaio	51	62
Subtotal	731	887
Auto	196	238
Utusia	33	40
Amaua	79	96
Fagaitua	457	555
Alofau	409	496
Subtotal	1174	1425
Amouli	324	393
Auasi	77	94
Utumea	43	52
Aoa	345	419
Tula	345	419
Subtotal	1134	1377
TOTAL		3689
GRAND TOTAL	23,994	46,085

SYSTEM DEMAND DESIGN CRITERIA

General

The determination of demands is one of the first major tasks in analyzing a water system. This data is used as the determining factor in evaluating the adequacies or shortcomings of the water supply and distribution system and to estimate the size of the facilities that will be required in the future. There is a very serious lack of data collected on the existing system in American Samoa that can give accurate information on the system's operating characteristics. Only 25% of the consumers and sources are metered and there is no data on pressure or flow rates within key points of the system. Some data has been collected during the past year, but the limited amount requires that consumption and variations in demand and flow rates be estimated. It should also be understood that this engineering evaluation assumes that the A.S.G. water system will be extended along the entire southshore of Tutuila Island as proposed by the A.S.G.

Per Capita Water Consumption

Data obtained over a four month period between October 1977 and January 1978 indicates that the estimated overall residential consumption of water varies from 264 to 319 gallons per capita per day (Table IV-4), while consumption on metered residential connections was estimated at 56 gallons per capita per day. The disparity between these two figures may be due to the limited accuracy of the data collected, but it is also an indication of waste and misuse of water within the system.

We estimate that the long term average day residential demand will be about 150 gallons per capita per day. Considerations used in arriving at this figure are as follows:

ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

TABLE IV-4

EVALUATION OF WATER CONSUMPTION [1]

Month	Estimated Total Volume of Water Used (MGD)	Metered Consumption (MGD)	% Metered	Total Residential, Commercial & Industrial (2)	Residential (2) Only	Industrial & Commercial (2) Only	Metered Residential (3)
Oct. '77	4.35	1.06	24.4	325	278	47	59
Nov. '77	5.14	1.30	24.1	385	319	66	58
Dec. '77	4.25	1.32	31.1	318	264	54	45
Jan. '78	4.37	1.11	25.3	237	279	48	63
Avg.	4.50	1.20	26.2	316	285	54	56

[1] Data from "G.A.S. System Water Usage" reports prepared by Department of Public Works Water, Sewer, Solid Waste Division. (See Appendix A)

[2] Based upon A.S.G. estimate of 13,350 people served by the water system.

[3] Based upon 7.4 persons per account, one residence per account.

1. Although the existing domestic consumption of metered residences is estimated at 56 gallons per capita per day, domestic consumption will increase as standards of living increase.

2. Metered residences may also be served by village water systems which would contribute to an artificially low metered residential consumption because of a preferential use of the free village system water.

3. The present overall domestic commerical and industrial consumption of 237 to 385 gallons per capita per day will be reduced as meters are installed throughout the system.

4. As it exists, the water distribution system has many built in characteristics that contribute to water waste and misuse. Many of these characteristics will never be entirely eliminated, and overall consumption is likely to remain at a relatively high rate. With an effective conservation program, residential water consumption could easily be reduced to 120 gallons per capita per day. We have added a 25% loss rate to obtain our recommended rate of 150 gallons per capita per day.

5. Because of prevailing local attitudes towards paying for water, the rates charged for water are likely to remain low contributing to higher consumption rates.

6. The data base from which the existing consumption rates have been calculated is for a very limited period and contains estimates of water production and population served. Consumption estimates should, therefore, be conservative until additional data is available.

Service Levels

Distribution and storage systems must be separated into service levels to maintain adequate pressures at high elevations and to prevent excessive pressures at low elevations.

The maximum static pressure should not exceed approximately 100 psi. Pressures above 100 psi can cause plumbing problems and contribute to leaks and excessive water usage. Setting the maximum pressure at 100 psi fixes the lower elevation boundary of the service level at a specific vertical distance below the storage reservoir overflow. Since 100 psi is the pressure exerted at the base of a column of water 231 feet high, the lowest consumer in the service level should not be more than 231 feet below the overflow of the storage reservoir.

The minimum static pressure at a customer connection should not be less than 25 psi. Pressures below 25 psi will not allow modern water using appliances and equipment to function properly. Setting the minimum pressure at 25 psi fixes the upper elevation boundary of the service level at a specific vertical distance below the storage reservoir overflow. To maintain a static pressure of 25 psi (equivalent to a column of water 58 feet high) the upper service level boundary should be at least 58 feet below the storage reservoir overflow. In addition, approximately 42 feet is necessary to satisfy the distribution system hydraulic requirements, giving a total minimum height of 100 feet.

The distribution system hydraulic requirements are made up of the daily fluctuation in the reservoir water level (10 to 15 feet) during the peak demand period and an additional 27 to 32 feet of pressure head required to force water through the distribution pipelines to the consumer's service.

Based on the above general considerations, the A.S.G. water system will require seven service levels (Table IV-5). These seven service levels can supply water from sea level to Aoloaufou Village at elevation 1375 feet above sea level. Figure VI-12 shows service level areas of the study area.

In the Bay Area, Utulei, Fagatogo and Pago Pago Village are becoming so densely developed that residences are now being constructed on the hillsides above the villages and above the effective service elevation of service level one. A second service level must be developed in these villages if the homes are to receive water.

Variations in Flow Rates

There are no records of the variations in hourly, daily or monthly water flow rates or pressures for the A.S.G. water system. Records from many water systems in the United States indicate that the maximum daily flow varies from approximately 1.2 to 2.5 times the average daily flow. For Samoa, we recommend a factor of 1.5. Lawns and gardens rarely require irrigation during the dry season in Samoa, and a low peak day factor results.

The supply facilities should be able to provide at least the average demand on the day of the maximum system demand. Hourly peak demands in excess of the average are most economically supplied from distribution system storage reservoirs.

Peak hourly flow rates are generally 2.5 to 3.5 times the average flow rates depending upon the service area involved. For Samoa, we recommend an average factor of 3.0 be used. Minimum daily flow rates will, in general, vary from 25 to 50 percent of the average daily flow rates. The estimated peak day flow rates for the study area for the estimated year 2000 populations are shown in Table IV-6.

Item No. 35. Nuuuli Village: This project will provide for replacement of the existing old 6-inch pipeline that feeds the airport from Vaitele Stream. The pipeline dates back to WWII and is subject to frequent breaks.

Item No. 36. Water Purification: This program will provide chlorination equipment for many of the new wells that currently are not chlorinated.

Item No. 37. Chlorinator Conversion: Based upon the report "Disinfection of Ground water Supplies, American Samoa" (CH2M-Hill, 1977), the government intends to upgrade its chlorination equipment. This program will provide for design, procurement and installation of the new equipment at eight different sites.

Item No. 38. Rechlorination: This project will consist of design and construction of a rechlorination station near Fagaalu so that chlorine residual can be maintained in the water pumped from Tafuna to the Bay Area.

Items Nos. 39 and 40. Treatment Facilities: These projects are for improved treatment facilities for surface water sources at Vaipito, Fagatogo, Fagaalu and Vaitele streams.

Item No. 41. Leak Detection: This program is for the procurement of equipment, training of personnel and institution of a leak detection program for the existing water system. The training of personnel under this program began in April of 1978.

Item No. 42. Malaeimi Pipeline: This project is for the construction of a pipeline back into the Malaeimi Valley for transmission of water from proposed wells in the valley to the water system. The project is contingent upon acquisition of well site right-of-ways and successful well drilling and testing.

Item No. 43. Operation and Maintenance Manuals: This project calls for a program to develop operation and maintenance manuals for the A.S.G. water system. The program will include system operation procedures, maintenance requirements and mapping of the water system that will accurately show the size and location of all pipelines and valves, interconnection details and other water system appurtenances on the transmission and distribution system.

Item No. 44. Meter Programs: This program is for obtaining more complete operating data on the water system. Meters will be installed on all water supply sources and at key points within the distribution and transmission system.

Items Nos. 45, 46, and 47. Miscellaneous Improvements FY 77, 78, and 79: This is a program for contingency improvements for pipeline failures, connections, well repairs and construction.

TABLE IV-5

RECOMMENDED SERVICE LEVELS

Service Level No.	Reservoir Elevation Base	Reservoir Elevation Over Flow	Service Level Boundary Elevations[1]	Normal Operating Pressure Range (PSI)
1	190'	222'	0 - 125'	24 - 96
2	320	352	125 - 250	26 - 98
3	450	482	250 - 375	28 - 100
4	580	612	375 - 520	22 - 103
5	725	757	520 - 665	22 - 103
6	870	902	665 - 810	22 - 103
7	1435	1467	1225 - 1375	22 - 105

[1] Elevations in feet above mean sea level.

TABLE IV-6

YEAR 2000 PEAK DAY FLOW RATES

No.	Service Area	Yr. 2000 Population	Industrial Allowance (MGD)	Residential[1] (MGD)	Total[2] (MGD)
1	Amanave to Amaluia	2430	-	0.547	0.547
2	Leone, Taputimu, Vailoatai	5031	0.05	1.132	1.182
3	Malaeloa, Pua Pua	1000	-	0.225	0.225
4	Futiga, Pavaiai, Mesepa	3866	-	0.870	0.870
5	Mapusagafou (lower)	706	-	0.159	0.159
6	Mapusagafou (middle)	350	-	0.079	0.079
7	Mapusagafou (upper)	350	-	0.079	0.079
8	Aoloaufou, Aasufou	1081	-	0.243	0.243
9	Iliili	1622	-	0.365	0.365
10	Faleniu, Mapusaga, Malaeimi	2390	0.07	0.538	0.608
11	Vaitogi	1617	-	0.364	0.364
12	Tafuna, Nuuuli	7689	0.25	1.730	1.980
13	Faganeanea, Fatumafuti	786	-	0.177	0.177
14	Fagaalu, Utulei, Fagatogo	5979	0.20	1.345	1.545
15	Pago Pago to Aua	7800	0.90	1.755	2.655
16	Tafananai to Avaio	887	-	0.200	0.200
17	Auto, Fagaitua, Alofau	1425	0.05	0.321	0.371
18	Amouli, Tula	1377	-	0.310	0.310
		46,086	1.52	10.439	11.959

[1] 150 gallons/capita/day x 1.5 peak day flow rate

[2] Peak day rate = population x 150 gallons/capita/day x 1.5 peak day flow factor + industrial allowance

Fire Protection

Water usage for fire protection varies with the use of the property to be protected. Although the total quantity of water used is small, the rates of use are quite large. The water distribution system must have sufficient capacity to supply water for fighting fires in addition to maintaining adequate flows to residential, commercial and industrial customers. The National Board of Fire Underwriters established minimum standards for the quantity and duration of flow for fire fighting purposes. The standards were developed to measure a water system's ability to fight fires and are used in determining the rates for an area's fire insurance premiums. The standards have also evolved into fire protection guidelines for design of water systems.

The fire flows required in higher value business districts are generally based on the total population of the area served by the business district. Fire flows in residential areas are based on the size, structural condition, value, and density of the dwelling units. Fire flows for institutions, industrial buildings, and suburban commercial complexes are usually evaluated separately. The recommended fire flows for American Samoa are shown in Table IV-7.

The existing fire protection system consists of fire hydrants throughout the distribution system and fire stations with pumper capacity at Leone and Fagatogo. The design of the recommended system assumes that the fire fighting capabilities will be continued to be upgraded and will be able to provide pumper truck fire fighting capabilities to all areas served by the A.S.G. water system.

TABLE IV-7

MINIMUM RECOMMENDED FIRE FLOW REQUIREMENTS

	Recommended Fire Flow		
Location	Quantity, gpm	Duration, hours	Volume mg
Principal Business District			
Population Served			
1000 or less	1000	2	0.12
2000	1500	2	0.18
5000	2250	2	0.27
10,000	3000	3	0.54
Future Industrial Tracts	3000	3	0.54
Typical Elementary School	1500	2	0.18
Typical High School, College or Church	3000	3	0.54
Single-Family Dwelling Area	1000	2	0.12
Multiple-Family Dwelling Area	2000	2	0.24

Pipeline Size

Transmission and distribution pipelines should be sized to provide the maximum daily flow plus fire flows with a residual pressure of 25 psi at the critical fire hydrant. In determining the carrying capacity of mains, the following "C" valves will be used:

PIPE SIZE	HAZEN AND WILLIAMS COEFFICIENT OF FLOW "C"
4", 6"	100
8", 12"	110
16", 20"	120
24" and larger	130

The maximum velocity of flow in mains should be 6 feet per second, without fire flows. With fire flows, the maximum velocity of flow should be 10 feet per second.

Storage Reservoir

The system's storage reservoirs should provide adequate storage to meet the following criteria:

1. The maximum day consumption with no source input to the reservoir. Reservoir is full at the beginning of the 24 hour period.
2. The maximum day consumption plus fire flows for the fire duration shown in Table IV-7 (reservoir 3/4 full at the start of the fire) with credit for incoming flow from source or booster pumps, with one of the largest pumps out of service.

The recommended reservoir sizing based upon this criteria is shown in Table IV-8. This table compares the requirement based upon criterion

TABLE IV-8

RESERVOIR SIZING

Location	Max. day[1] sizing (MG) (1)	Fire reserve (MG) (2)	Max. day & fire res. (MG) (3)	3/4 full (MG) (4)	Incoming flow (MG) (5)	Total (MG) (6)	Use[3] (MG) (7)	Say[4] (MG) (8)
Amanave Reservoir	0.547	0.27	0.817	1.089	-0.547	0.542	0.547	0.75
Leone Reservoir(s)	1.182	0.54	1.722	2.296	-1.886	0.410	1.182	1.50
Futiga Reservoir	0.225	0.54	0.765	1.020	-1.886	-	0.225	0.25
Mapusagafou #1	0.870	0.18	1.050	1.400	-0.56	0.840	0.840	1.0
Mapusagafou #2	0.159	0.12	0.279	0.372	-0.159	0.213	0.213	0.25
Mapusagafou #3	0.079	0.12	0.199	0.265	-0.079	0.186	0.186	0.25
Mapusagafou #4	0.079	0.12	0.199	0.265	-0.079	0.186	0.186	0.25
Iliili Reservoir	0.365	0.18	0.545	0.727	-1.56	-	0.365	0.50
Vaitogi Reservoir	0.364	0.12	0.484	0.645	-0.364	0.281	0.364	0.5
Tafuna, Nuuuli	1.980	0.54	2.520	3.360	-7.238	-	1.980	2.0
Faleniu, Mapusaga, Malaeimi	0.608	0.54	1.148	1.531	-7.238	-	0.608	0.75
Faganeanea, Fatumafuti	0.177	-	-	-	-	-	N/A	N/A
Fagaalu, Utulei, Fagatogo	1.545	0.54	2.085	2.780	-5.081	-	1.545	2.0
Pago Pago, Aua	2.655	0.54	3.195	4.260	-5.081	-	2.655	3.0
Laulii to Alega	0.200	0.18	0.38	0.507	-0.881	-	0.20	0.25
Auto, Fagaitua, Alofau	0.371	0.54	0.911	1.215	-0.681	0.534	0.534	0.75
Amouli, Tula	0.310	0.18	0.49	0.653	-0.31	0.343	0.343	0.50

1. From Table IV-6.
2. From Table IV-7.
3. Use maximum column 1 or 6.
4. Rounded up to nearest 0.25 MG.

one (column one) and criterion two (column six), selects the larger of the two (column seven) and adjusts the requirements to fit the situation (column eight).

Pump Capacity

Booster pumping stations should be adequate to meet 1) the maximum day demand with an operating time of 16 hours and 2) the maximum day demand plus fire demands during the duration of a fire, less 3/4 of reservoir storage. In all cases, the largest unit will be considered out of service.

CHAPTER V

IDENTIFICATION OF PROBLEMS

CHAPTER V

IDENTIFICATION OF PROBLEMS

SURFACE WATER SUPPLIES

General

Prior to the 1970's, water supplies in American Samoa were almost exclusively from surface water streams, and water supplies came directly from the streams with little or no storage provided. These streams were adequate for use by a relatively small population with a small per capita demand for water and a low expectation for the quality of service. During periods of low rainfall and restricted water supplies, the population survived with some inconvenience and economic hardship through water rationing.

Without storage, surface water reservoirs can only be relied upon to supply water at their low flow rates. A surface source is only as good as its dry season flow unless higher than normal flows can be stored for use during low flow periods.

Available Storage

Unfortunately, the steep, narrow stream valleys of American Samoa do not provide easily available sites for storage reservoirs of sufficient capacity to supply water during the four to six month Samoan dry season. A water system relying entirely on surface water would require several hundred million gallons of water in storage to meet the design year water demands through a dry season. The largest existing reservoir in American Samoa is at Virgin Falls on the Fagaalu Stream. This reservoir is approximately 25 feet high and holds approximately 4.5 million gallons of water. A hydrologic study of surface water (Dames & Moore 1978) showed that approximately 164 million gallons of storage would be required for each million gallons per day of regulated flow.

Available Supplies

The American Samoa Government does not maintain any accurate long-term flow records of its surface water sources, and all past water supply planning studies were necessarily based upon estimates of low flows. The record droughts of 1971 and 1974 indicated that all previous estimates were overly optimistic (Table III-2). During each of these years, the total flow from five of the major stream sources for the A.S.G. water system dropped to approximately 250 gallons per minute.

One major advantage of utilizing surface water in American Samoa is that some of the sources are located closer to the point of consumption in the Bay Area (Pago Pago) eliminating the need for long transmission pipelines and booster pumping stations. This single advantage is more than offset by the tendency of surface waters to vary greatly in quality and quantity from day to day and by the complex treatment required to meet current federal water quality standards. The relatively low flows available from a single stream and the random spacing of each stream throughout the water system require that the complex treatment equipment be duplicated in many locations compounding the maintenance and operation problems.

Watershed Protection

Surface water supplies require strict protection of watersheds from contamination. All human, residential, agricultural, and recreational activities should be controlled within a designated watershed area that is above a surface water intake.

In American Samoa, agricultural and recreational activities such as hiking and bathing often take place in the watersheds of the existing surface water supplies. Competition for housing sites is forcing residential developments higher and higher up hillsides behind existing villages, seriously threatening most watersheds. Although restrictions are needed, the A.S.G. does not currently exercise any control over use of the watershed lands above its surface water sources.

Water Quality

The R.M. Towill Corporation investigated the Bay Area surface water treatment systems (R.M. Towill, 1973). Even with somewhat optimistic estimates of the minimum flow rates available, they recommended that the surface water sources be abandoned. This recommendation was based upon the following conclusions:

1. The existing treatment equipment is inadequate for the conditions in which it is operated. To operate satisfactorily, the existing equipment needs to be repaired and upgraded by the addition of provisions for pretreatment, pre and post chlorination and monitoring of the system operations.
2. Economic considerations of expenditures to upgrade the system are not justified considering the small quantity of end product produced.
3. The degree of watershed protection to provide a 100% safe water supply does not appear culturally or politically acceptable to the community.
4. There is insufficient quantity of technically qualified operational personnel to maintain the relatively complicated treatment processes required.
5. Public health considerations indicate that a water supply should be abandoned if it is potentially dangerous because of possible human error, mechanical malfunction, or other factors beyond the control of the system operators.

Past experience with the filters support the above recommendations. The filters have been repaired and recharged two or three times in the past eight years, and within a short period they were inoperable. The limited number of technically qualified operational personnel did not have the time required to keep the filters functioning.

In recent years, the Department of Public Works has increased its efforts at inservice training and maintenance of the treatment facilities and has reported an improved operating record. However, the basic inadequacy and unreliability of the equipment to operate correctly under the varying quality of water remains.

GROUND WATER SUPPLIES

General

The natural quality of fresh ground water in American Samoa is very good. It can meet the maximum contaminant levels set forth in the National Primary Drinking Water Regulations for the parameters measured and is suitable for domestic consumption and current industrial uses in American Samoa. Since the early 1970's, the A.S.G. has directed its water source development toward ground water supplies, and the quantity and quality of water service has steadily improved. The improvement in service, however, has not been without certain problems due primarily to the previous lack of technical expertise and other management and training needs.

Existing Resources and Problems

The basal ground water lens that is viewed as the primary source of water for Samoa is located in a limited area known as the Tafuna-Leone Plain. While this area has great potential for residential and commercial development and is rapidly growing, the major water system demands are currently within the Bay Area some six miles distant from the well sources. Because of its length, the transmission line is vulnerable to breaks and power outages which can cut water service. The well pumps and booster pumping stations require expensive electrical power and sophisticated technical maintenance capabilities. These shortcomings have created past operational problems with the ground water sources.

Recent tests of new booster pumping facilities at Fagaalu and Pago Pago have indicated that there are an insufficient number of wells on line to support the transmission facilities. The imminent addition of pumps to existing new wells should relieve this problem.

The ground water reservoir in American Samoa is replenished continuously, but it is a finite resource that can be over-taxed if care is not exercised on the rate of withdrawal. Inadequate monitoring and management of the development of the resource has caused seawater intrusion at several wells. The effect of ground water withdrawal on the entire basal lens has not been determined; thus, overdevelopment of the lens is a constant threat.

Right-of-Way Problems

Right-of-way for construction of wells has been a continuing problem in ground water development. Right-of-way has been an especially acute problem for wells because they usually must be located outside of recognized areas of A.S.G. concern such as roadways, and the property owners can not see any direct benefit to themselves from the construction of the wells. The sites determined to have a high potential for production are relatively limited and it has become increasingly difficult to find land where right-of-way can be obtained by negotiation. This problem is examined in more detail in the right-of-way section of this chapter.

Public Support

There is very little public support for the water system development in general and the ground water program in particular. For the most part, the lack of support is due to a lack of communication between the Public Works Department and the general public. There should be an immediate and sustained effort to inform the people of Samoa of the objectives of the Ground Water Development Program. A public education and public involvement program listing the advantages and disadvantages of utilizing ground water and the current implementation problems should help to obtain public support. If the legislature and the public are kept informed, they could possibly lend their support to the program.

TREATMENT

General

Existing treatment of the water supplies is limited to chlorination of some ground water sources and filtration and chlorination of the surface water sources. Because of operational problems, the filters are sometimes bypassed. The degree of control over water quality is generally very poor.

The treatment of ground water is limited to the wells in the Tafunafou well field and a few other isolated sources such as the shallow dug well at Utulei which serves the hotel. Because of the problems in obtaining right-of-way, many of the recent wells have been drilled at scattered locations. Separate chlorination equipment may have to be installed and maintained at each of these wells if the water is to be chlorinated before all customer connections.

Filtration

Pressure filters have been installed at the Vaitele, lower Fagaalu and Fagatogo surface water sources. Attempts have been made on several occasions to activate these filters, however, the water supplied to these filters is of such a varying quality and becomes so poor at times that the filters are difficult to operate correctly. The equipment does not provide for proper backwashing to clean the filters and there is insufficient operator time and technical capabilities to give them adequate care.

The three automatic gravity filters at Vaipito Reservoir have similar operating problems to the pressure filters and in the past were frequently bypassed. For a more complete discussion of the surface water treatment facilities see The Analysis of Vaipito and Fagaalu Treatment Systems, R.M. Towill Corporation, 1973.

Chlorination

The chlorination equipment throughout the system is inadequate. Chlorine is applied only at some of the sources of supply and chlorine residuals are not maintained throughout the system. Contact times are insufficient and the equipment has no provision for automatic switchover to a standby supply when one supply bottle has been exhausted. Several days often elapse before maintenance personnel can replace the exhausted supply containers.

For a more detailed discussion of the existing treatment system see Disinfection of Ground Water Supplies, CH2M-Hill, 1977.

TRANSMISSION AND PUMPING

General

Vast improvements in transmission and pumping capabilities of the A.S.G. water system have been accomplished in the past six years. The area served by A.S.G. water systems has greatly expanded from the original Tafuna and Bay Area population centers. The ability to move water into and through these areas was one of the main objectives of the past water system improvement programs.

Transmission Pipelines

However, because of the excessive water consumption identified in Chapter IV, two shortcomings currently exist within the system. Adequate operating pressures within the Pago Pago Bay Area (Tables V-1 and V-2) cannot be maintained in the 12-inch diameter pipelines that extend from Nuuuli to Fagaalu and from Utulei to Malaloa. This inadequate flow capacity and the insufficient supplies from the Tafunafou well field also prevent the operation of the two new booster stations at Fagaalu and Pago Pago. If water consumption could be reduced to a more reasonable level of 150 GPCD (see following discussion on the distribution system in this chapter) and more of the existing wells were operational, these facilities would be adequate to meet current demands (Table V-3 and V-4).

The other transmission pipelines in the A.S.G. system are normally capable of supplying current water demands. Villages beyond the existing A.S.G. system have critical deficiencies. The expansion of the A.S.G. system to these areas should be preceeded by studies to determine the desires and expectations of the villages involved and the adequacy of existing source and transmission facilities to handle the

TABLE V-I

PEAK 1978 FLOW RATES
FOR A.S.G. WATER SYSTEM

Service Area	1978[1] Population	Industrial Demand (MGD)	Residential[2] Demand (MGD)	Total Flow (MGD)	Cummulative Flow (MGD)
Tafuna	845	0.01	0.390	0.400	5.785
Nuuuli	2160	-	0.998	0.998	5.385
Faganeanea	496	-	0.229	0.229	4.387
Fagaalu	968	0.01	0.447	0.457	4.158
Utulei	965	-	0.445	0.445	3.701
Fagatogo	1842	-	0.851	0.851	3.256
Pago Pago	2605	-	1.204	1.204	2.405
Canneries	1084	0.70	0.501	1.201	1.201
	10,965	0.72	5.065	5.785	

[1] 1974 Population plus 3%.

[2] Estimated November, 1977 average daily flow rate (385 GPCD) x 1.2 peak day factor x population.

[3] Assumes no surface water inflow.

TABLE V-2

HYDRAULIC GRADE LINE
FOR A.S.G. WATER SYSTEM
1978 PEAK DAY FLOW

Location	Flow Rate MGD	Flow Rate GPM	Pipe Size (in)	Head loss ft/1000 ft	Length (ft)	Head loss (ft)	Elevation HGL
Well Field							260
	5.785	4017	16	9.8	2000	20	
Highway Road							240
	5.785	4017	20	3.2	2500	8	
Airport Road							232
	5.785	4017	24	1.24	2500	3	
Housing Road							229
	5.385	3740	24	1.04	7500	8	
Coconut Point							221
	4.387	3046	12	26.6	12,000	319[1]	
Fagaalu Booster							-98 to 245
	4.158	2887	20	1.7	7500	13	
Utulei							232
	3.701	2570	12	19.5	7000	137[1]	
Malaloa							95
	3.256	2261	16	3.8	1500	4	
Pago Booster							89 to 245
	2.405	1670	16	1.8	1000	2	
Pago Pago							243
	1.201	834	12	2.3	5500	13	
Canneries							230

[1] Critical pressure drops creating low pressures within water system.
Assumes distribution reservoirs do not contribute to system during peak flow.

TABLE V-3

PEAK 1983 FLOW RATES
FOR A.S.G. WATER SYSTEM

Service Area	1983[1] Est. Pop. Served	Industrial Demand (MGD)	Resi-dential[2] Demand (MGD)	Total Flow (MGD)	Cummu-lative Flow (MGD)
Tafuna & Vaitogi	2005	0.01	0.451	0.461	3.811
Nuuuli	2932	-	0.660	0.660	3.350
Faganeanea	674	-	0.152	0.152	2.690
Fagaalu	1114	0.01	0.251	0.261	2.538
Utulei	1110	-	0.250	0.250	2.277
Fagatogo	2118	0.01	0.477	0.487	2.027
Pago Pago	2996	-	0.674	0.674	1.540
Atuu, Anua & Canneries	738	0.70	0.166	0.866	0.866
	13,697	0.73	3.081	3.811	

[1] Per A.S.G. Development Planning Office.

[2] Population x 150 GPCD x 1.5 Peak Day Factor.

[3] Assumes no surface water inflow.

[4] Flow is conservative as not all residents of Bay Area are on system (many homes are above 175 foot effective service elevation or are on private water systems).

TABLE V-4

HYDRAULIC GRADE LINE FOR A.S.G. WATER SYSTEM 1983 PEAK DAY FLOW

Location	Flow Rate MGD	Flow Rate GPM	Pipe Size (in)	Head loss ft/1000 ft	Length (ft)	Head loss (ft)	Elevation HGL
Well Field							260
	3.811	2646	16	4.2	1500	6.3	
Highway Road							254
	3.811	2646	20	1.4	2500	3.5	
Airport Road							250
	3.600	2500	24	0.46	2500	1.15	
Housing Road							249
	3.300	2292	24	0.43	7500	3.2	
Coconut Point							246
	2.690	1868	12	9.6	12,000	115	
Fagaalu Booster							131 to 245
	2.538	1763	20	0.65	7500	4.8	
Utulei							240
	2.277	1581	12	8.3	7000	58	
Malaloa							182
	2.027	1408	16	1.4	1500	2.1	
Pago Booster							180 to 24[illegible]
	1.540	1069	16	0.91	1000	0.9	
Pago Pago							244
	0.866	601	12	1.2	5500	6.6	
Canneries							237

Assumes distribution reservoirs do not contribute to system during peak flow.

increased water demands. Controls should be maintained over consumption in the new areas so that excessive demands are not imposed on water delivery facilities.

The A.S.G. is currently conducting a leak detection survey on the transmission system. Preliminary results indicate that the transmission system is in good condition. One of the problems highlighted in the survey was a lack of system mapping. Being able to determine the location of existing pipelines, interconnections and valves is important in the effective operation of the water system.

Booster Stations

Booster stations are required to increase the system's reliability in the upper service areas. The villages of Vaitogi, Iliili, Futiga, Pavaiai, and Mapusagafou are currently subject to shortages when either the single surface source (Puna Dam) or the well at Iliili is not operating or cannot meet demands. The booster stations would lift water from the lower service level to supplement these sources.

The maintenance and operation of booster pumps is also a serious problem due to several factors. The moist tropical environment of American Samoa shortens the life of all mechanical devices. Severe voltage drops and surges are common and are extremely hard on electric motors and other electrical equipment. Pumps are frequently operated under other than design conditions. There is a critical shortage of technically skilled manpower for the operation and maintenance of the many pumps and motors. The repair staff is frequently in an operational crisis because of low pressures or lack of water. A preventive maintenance program is almost impossible under these conditions. Too few standby facilities are provided and spare parts are difficult to obtain so that repairs are often just temporary expediences.

The 100 horse power pump in the older booster station at Nuuuli is operated with reported success. The actual benefit is difficult to determine, however, as limited records of flow rates or pressures are maintained for each station. The pump is no doubt operated in a very low efficiency range as the system demands are far above the pump's design flow rates. This station should be abandoned when the new booster stations at Nuuuli and Pago Pago are made operational.

DISTRIBUTION STORAGE

General

The existing A.S.G. water system contains 3.5 million gallons of distribution storage in the Pago Pago, Maugaalii, Blunts Point, and Tafuna Reservoirs.

Elevated distribution storage is usually provided within distribution systems to normalize system pressures and supply peak water demands. Elevated distribution storage may also be provided to increase system reliability and to reduce the need of constructing large main sizes to the system extremities. Elevated storage facilities are designed so that the system hydraulic gradients fall within the useful elevation range of the tank; thus, allowing the tank to contribute its volume by gravity. Facilities operated in this manner are referred to as "floating" storage facilities. Elevated distribution storage provides increased reliability for fire protection and for emergencies during power outages or other high service pumping interruptions.

Operation

High consumption rates and limited water resources have prevented A.S.G. storage reservoirs from operating as distribution system reservoirs as they were intended. Attempts to let the reservoirs "float on line" in the Bay Area result in continuously empty reservoirs. Currently the reservoirs store excess water accumulated during wet weather periods. This excess water is pumped into the reservoirs and retained for dry weather and other emergency purposes. The Pago Pago Reservoir is used primarily for emergency service to the canneries and the Pago Pago area, the Maugaalii Reservoir serves the downtown Fagatogo area, and the Blunts Point Tank serves the hospital and Fagaalu and Gataivai Villages.

The problem with utilizing the reservoirs in this manner is that the water system loses its ability to draw from the reservoirs during the peak hour demands of each day. All supplies must come directly from the sources, which overloads the capacity of the source and the transmission mains and results in low operating pressures throughout the system.

Capacity

The Tafuna area and upper service areas around Futiga and Pavaiai are deficient in storage facilities for current peak hour and fire reserve demands. Existing storage is limited to 0.5 million gallons at Tafuna and 90,000 gallons near Mapusagafou. A 0.75 million gallon reservoir is under construction at Pavaiai. The three million gallons of storage capacity in the Bay Area is adequate for existing peak hour and fire demands if the reservoir water levels can be maintained.

Maintenance

All of the existing reservoirs require painting and repair of automatic control valves before they can float on line. The reservoir at Pago Pago is currently threatened by an active earth slide.

DISTRIBUTION SYSTEM

General

The existing distribution system is and has been a source of problems for the water system for many years. Austin-Smith & Associates pointed to excessive water use in the initial 1963 report on the A.S.G. water system. Most of the subsequent water studies also noted excessive water demands as a major problem.

Data collected by the Department of Public Works covering the period from October 1977 to January 1978 indicates that nearly half of the water used cannot be accounted for (Appendix A). This does not mean that it is not metered, but it means that after estimating all normal residential, commercial and industrial use, nearly an equal amount is lost somewhere within the system.

Water Consumption

Only about a quarter of all water consumed is metered, but the metered residential customers average only 56 gallons per capita per day in consumption. This figure has been indirectly calculated and is only approximate, but it reflects the amount of conservation that can be obtained through metering and nominal water use charges. Total residential water use among metered and non-metered customers is estimated at 285 gallons per capita per day. This figure includes the unaccounted for water and illustrates how great a problem the excessive water consumption is to the water system. For comparative purposes, 150 gallons per capita per day would be considered a generous consumption rate for an area like American Samoa.

The unaccounted for water includes unnecessary consumption and wastage. The production, transmission and distribution of this water puts a strain on the system facilities, consumes unnecessary electric power and has required premature investment in plant and equipment.

A.S.G. facilities including employee housing are not metered and do not pay for water consumed. The volume of water consumed by these facilities is potentially quite large as there is no incentive for conservation. There should be an administrative policy developed concerning this matter to bring about a reduction in water consumption and to eliminate the double standard between A.S.G. employees and the community at large.

Backflow

The negative pressures created in the pressure fringe areas during high demand hours dramatically increase the possibility of backflow contamination of the entire water system. There is little plumbing code enforcement, and cross connections with private water systems, ground surface pipelines running through pig pens or other contaminated areas and other possible sources of backflow are evident throughout the distribution system.

Most direct cross connections with the main transmission lines of village systems have been reported to be eliminated or protected with double check valves. Cross connections with the village systems within individual homes, however, presents an equally serious potential for contamination of the A.S.G. system.

Water Service Policy

The A.S.G. has been over accommodating in the past in providing service to customers. Service laterals extend far from main pipelines to the point of consumption and meters are usually installed at or near the residence. The portion of the service lateral that is behind the meter becomes the maintenance responsibility of the A.S.G. as any water lost would not be metered and the customer would not be concerned. Because of the difficulty in obtaining right-of-way and for simple expediency, the service laterals are usually constructed on the ground surface where they are subject to damage and illegal connections. Most laterals are either galvanized iron or plastic and are easily tapped illegally by anyone desiring water. To complicate matters, most villages also have private water systems. It is difficult to locate illegal connections in the web of A.S.G. and private small diameter pipelines that intertwine throughout most villages.

The A.S.G. provides water service to customers who are above the elevation that will allow proper pressures in the water system. Water is available to these customers only when other demands on the system are low and water pressures rise. Pressures usually rise late at night or in the early morning. The customers leave their taps open over a large drum in an effort to collect as much water as possible during the night. If the drum overflows, it is regretable, but at least a full drum was collected. These high elevation fringe areas also have a higher proportion of illegal connections because they are the most remote from official inspections.

The A.S.G. needs to determine realistic service objectives for the water system and to set policy and service rules and regulations based upon these objectives. Even with unlimited financial, physical, and technical resources, the A.S.G. could not expect to be all things for all people. If standards are sacrificed in one area, customers in another are deprived of a proper water service.

RIGHT-OF-WAY

General

Right-of-way acquisition for water system improvements has been a serious problem for the Department of Public Works in recent years. Badly needed projects have been delayed or halted indefinitely by extended right-of-way negotiations or right-of-way disputes. Projects have been modified at increased cost or at the expense of the system operating efficiency in attempts to skirt right-of-way problems.

The Right-of-Way Program of the Department of Public Works is beset with problems in the areas of setting policy guidelines, continuity of trained personnel, budgeting requirements, abuse of the crop damage system, and landowner and boundary disputes.

History and Legal Precedence

The American Samoa Government aquisition of Samoan lands can be traced back to the United States Navy Administration of Samoa (C.A. No. 199-1964). The court has determined that since land owned by Samoans before the deed of cession to the United States in 1900 was retained by the Samoans after 1900, the land could only be obtained by the A.S.G. by negotiation or by condemnation under eminent domain (C.A. No. 25-1962).

The right of eminent domain is the power of a sovereign state to take or to authorize the taking of property in its jurisdiction for public use without the owner's consent. Eminent domain is an inherent sovereign right, founded on the common necessity and interest, to appropriate property of individuals for the greater needs of the community. The right of eminent domain is given to the American Samoa Government in Title 27, Section 1601 and Title II, Section 6401 through 6467 of the American Samoa Code. The power of eminent domain can be exercised only for what is deemed a public use and where just compensation is given.

The High Court of American Samoa has taken judicial notice (Rule of Evidence 201 of the High Court of American Samoa) that the most valuable tangible thing that Samoans possess is their land (C.A. No. 199-1964). In 1900 the U.S. Commander condemned land for a public highway, and it was deemed an appropriation for public use (C.A. No. 25-1962). The High Court of American Samoa determined that when condemnation proceedings are made for public use and when just compensation is paid, then it does not violate due process of law (C.A. No. 25-1950). The Court also found that land taken by the A.S.G. is not against the interest of the Samoan people, because the property is held by the A.S.G. for the use and benefit of all the people of American Samoa (App. Div. No. 15-1963).

In Re Matter Condemnation of Pago Pago Well Property , 1951, (2 A.S.R. 614), land in Pago Pago was taken by condemnation proceedings. In 1954, the American Samoa Government in The Matter of the Acquisition of Land for the Construction of the Airport (C.A. 15-1959), obtained a judgment from the High Court of American Samoa, condemning 550.83 acres of land at Tafuna for a public airport and granting ownership in fee simple to the Government of American Samoa. Fair compensation was set by the Court as follows:

1. $135 per acre for land cleared but without any plantation on it.
2. $140 per acre for bush or jungle land.

3. $380 per acre for land including the plantations thereon, the ownership of such land and the plantations being combined in the same family, families, person or persons.
4. $135 per acre for land (i.e., the land alone) on which there were plantations at the time of the taking, the ownership of the land and of the plantations theron being separated, i.e., not combined in the same family, families, person or persons.
5. $245 per acre of plantations (i.e., for the plantations alone), the ownership of the land and the plantations thereon being separated at the time of the taking, i.e., not combined in the same family, families, person or persons.

In 1961, in The Matter of the Condemnation of Dairy Farm Hansen's Disease Sanitarium Area and Access Roadway (3 A.S.R. 439), the A.S.G. filed a notice that there existed a dispute among the claimants regarding the ownership of the property and requested that the Court determine its ownership. The Court rendered a determination after a trial on the issue of ownership for the purpose of distribution of the condemnation award.

The condemnation proceedings used by the American Samoa Government in the Pago Pago Well Condemnation, Airport Acquisition, and the Dairy Farm cases were the same or similar to the condemnation proceedings provided for in the Revised Code of American Samoa. The Revised Code of American Samoa provides condemnation proceedings where the A.S.G. desires to acquire any land, easement, right-of-way, or other property interest for public use. The code provides for the right of compensation, the determination and award of compensation, disposition of disputes to title, the arbitration of compensation disputes and the appeal process.

In seeking to set forth guidelines for Right-of-Way acquisitions by the Department of Public Works, a Right-of-Way Manual was prepared. The manual provides general guidelines for organization of a Right-of-Way Branch, sets procedures for right-of-way acquisitions, the execution of instruments, the closing procedures, lead time or advance notice procedures, condemnation guidelines,payment of crop damage, and the relocation assistance regulations under the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (27 A.S.C. 2001).

Right-of-Way Policy

Policy problems may have resulted from the lack of continuity in the executive administration of the Territory of American Samoa. The Territory has had five appointed Governors and one elected Governor during the past five years. It is difficult to reconstruct the right-of-way policy for each administration, but it would appear from a review of the present situation that no substantive policy has been adopted.

A right-of-way policy is essential to the establishment of a viable program that will reduce delays during the negotiation stages of right-of-way acquisitions or when negotiation fails to result in an agreement and condemnation proceedings are initiated.

The problem with setting a viable right-of-way policy may also be attributed to the high turnover of A.S.G. contract employees in Public Works Department and the lack of a training program to train local personnel to administer a right-of-way acquisition program.

Crop Damage

Under the crop damage schedule, the owner receives fixed compensation for a list of "cash" crops destroyed by reason of the right-of-way acquisition in addition to payment for the right-of-way. The continued use by the A.S.G. of this system allows for abuses by the landowner. Crop damage abuse cases reported by the Department of Public Works have included the planting of crops within the area of the right-of-way after negotiations have begun and claims for crops destroyed which were not affected by the right-of-way acquisition. The inherent abuses within this system exist because of the lack of definite guidelines for Right-of-Way personnel and the lack of trained personnel that are bonded under surety to certify the accounting of the damage and the payment made to the landowner.

Budgetary Policy

There also exists a budgetary problem in regards to negotiating easements or leases for right-of-way acquisitions. In a situation where the right-of-way acquisition allows for monthly or annual payments, the landowner often requests an advance payment for the amount due over the term of the lease. The advance payment decreases the available money in the current budget and may not be adjusted in the next annual budget. The limited funds may limit the A.S.G. ability to negotiate fair compensation for required right-of-way acquisitions.

Land Title Registration

Most of the communal land in the Territory of American Samoa has not been surveyed and registered. Communal land ownership under the authority (pule) of the chief (matai) is subject to boundary disputes and disputes of actual ownership because of the lack of recorded boundaries. A common problem has been that the A.S.G. will enter into an agreement with a matai or a person who represents himself as the owner but is not the true owner or is only one of the owners. There is no formal procedure whereby the A.S.G. can obtain a verification of land ownership of communal land when the land has not been duly recorded. American Samoa does not have a title insurance company that can give certification of title to lands subject to right-of-way acquisitions.

The recordation of land sales and lease rentals does not have grantor-grantee index or a cross-index system to obtain an abstract of the sale. The same problem exists with the recordation of leases. The problem of the lack of registration of title to land in the Territory of American Samoa is indirectly related to the lack of adequate recordation of land sales and lease rentals in the Office of the Territorial Registrar. Land sale prices and lease rentals can be obtained by reviewing the Native Land Transfer Volumes and Native Lease Volumes in the Office of the Territorial Registrar, but the process is very time consuming. The present system provides for the recordation of the land sale or the lease by the village, the "name of the land", and in chronological order of presentation for recordation.

Past experience has shown that when the A.S.G. personnel enter into an agreement with the wrong landowner or with only one of the landowners, a matai or person believing to have a claim on the land will file a temporary restraining order against the American Samoa Government and the alleged landowner. The temporary restraining order will seek to have a preliminary injunction until ownership is determined in a trial in the Land and Titles Division of the High Court of American Samoa. Under the laws of American Samoa, any matter involving a land dispute must be referred to the Office of Samoan Affairs for at least two meetings and if the matter is not resolved, then a certificate of irreconcilable dispute is filed for trial with the High Court of American Samoa. This process is very time consuming and can result in delaying the matter for several years. Most temporary restraining orders in land dispute matters are granted without the posting of a bond and are easily obtainable upon merely filing a Complaint for Injunctive Relief, with an affidavit alleging irreparable damage and no adequate remedy at law to support a temporary restraining order.

VILLAGE SYSTEMS

General

There are over 40 villages that have water systems that are completely independent from the A.S.G. water system, except to the extent that they request A.S.G. assistance for repair or expansion to the system, or that they have schools or other A.S.G. facilities in them. There are probably an equal number of villages which maintain private water systems while using the A.S.G. water system as a backup supply.

Village water systems are distinguished from the A.S.G. water system for several reasons. The most significant of which is that the residents of American Samoa draw a careful distinction between them. The A.S.G. water system is the one that attempts to charge for water through the use of meters or flat rate use charges.

It is difficult to generalize about so many individual systems, each of which has features which make it unique from the others. There are, however, similarities that apply to the majority of the village water systems and these similarities will be discussed here.

Generally, village water systems are small, unplanned systems that have been developed over time to supply water to a village or a portion of a village. They have usually been constructed to provide minimal domestic flows. Pipe sizes are generally under two inches in diameter and storage is limited to that available behind the stream catchment (usually less than 2,000 gallons). The water supply is generally derived from surface water streams. With very few exceptions, these supplies are inadequate during the dry season.

The more remote the villages are from the westernized center in the Bay and Tafuna areas, the more independent from the A.S.G. they are in the administration of their villages. This independence is by design of the village councils who do not want control of village affairs to go to outside forces. The strict control over family and village life is part of the fabric of the Samoan culture. Almost without exception, the villages want to maintain control over their water systems, to maintain their independence and to avoid paying for water service. It is very difficult to explain to the villagers that the water charge is not actually for the water, but for the delivery and treatment system.

Water Quality

None of the villages treat their water in any way and the quality of water is usually very poor (Table V-5 and Figure V-1). The watersheds behind the catchment dams are cultivated by villagers and often are foraged by pigs. Suggestions to limit access or to set aside protected watersheds have been flatly refused by villagers since much of the village food supply comes from plantations situated in these watersheds. The ownership and control of these lands is vested in different family chiefs. Restricting the use of land by one or more families could cause serious political and cultural problems within the village.

The major difficulty with independent village water systems is that few villages have the technical or managerial ability to operate a reliable water system. The villages have gotten by in the past with the simple stream catchment systems when the expectations for the system were low. The villages are growing now, and almost all homes have indoor plumbing. The value of these homes is increasing, and they

TABLE V-5

SOME WATER RELATED DISEASES
REPORTED TO LBJ MEDICAL CENTER *

	1971	1972	1973	1974	1975	1976
Amebiasis	6	0	0	1	0	2
Bacillary Dysentery (Shigellosis)	0	1	0	0	1	1
Food Poisoning (Staph.)	1	2	8	2	0	0
Hepatitis, Infectious	13	51	13	24	44	14
Infantile Diarrhea (Hospital only)	155	130	120	119	126	132
Salmonellosis	3	1	0	2	0	4
Trachoma	9	4	0	0	0	0

* It should be kept in mind that often Samoans do not seek medical treatment for "mild diseases" such as gastroenteritis and dysentery.

Source: 1977 Annual Report to the Secretary of the Interior.

FIGURE V-I

PUBLIC NOTICE OF POOR WATER QUALITY

PUBLIC NOTICE

The Department of Health advises the following villages, Fagasa, Masausi, Masefau, Aoa, Ploa, Amanave, Agugulu, Se'etaga, Ataulama, Amaluia, Leone, Malaeloa, Ili'ili, Pava'ia'i and Faleniu to boil their drinking water for 20 minutes before consumption. The Public Health Laboratory Monitoring reports last week indicated that your water is unsuitable for drinking purposes.

You are strongly advised to stay away from streams and areas where catchments are located in order to eliminate contamination. You are also reminded that stray pigs and other domestic animals be kept away from these areas.

FAAALIGA

Ua Fautuaina e le Ofisa o le Soifua Maloloina le mamalu o alafaga nei: Fagasa, Masausi, Masefau, Aoa, Poloa, Amanave, Agugulu, Se'etaga, Atauloma, Amaluia, Leone, Malaeloa, Ili'ili, Pava'ai'i ma Faleniu, ina la faapunaina lelei le suavai mo le 20 minute a e le'i faaaogaina mo le taumafa. Ua faaalia i su'esu'ega a le Ofisa o le Soifua Maloloina i le vaiaso ua ta'a, le le talafeagai o le suavai mo le taumafa.

E lapata'i atu ai i lo outou mamalu ina la alo'alo ese mai vaitafe ma faatanoa, ina la taofia ai lona faaleagaina. E faamanatu atu foi i lo outou mamalu o mea-itua-olo ta'aloa, ma nisi mea oia la teena mai nei laufanua.

Source: Samoa News, Friday, May 19, 1978, Vol. 8-5187 warrant fire protection. Villagers are beginning to recognize the health benefits of a quality water supply, and federal regulations (PL 93-523) will soon place strict requirements over the quality of water that may be supplied in any water system with 25 or more consumers.

American Samoa Government Policy

The A.S.G. lacks a clear or workable policy for dealing with the village water systems. While customers on the A.S.G. system are required to pay for water service with the explanation that the revenues indirectly go toward the operating and maintenance costs for the water system, in contrast, if a village keeps requesting assistance, they will eventually get free repair service or funds for improvements to their water systems. In some instances, the A.S.G. will provide assistance to a village that also has access to the A.S.G. water system. It is not surprising, therefore, to find that people on the A.S.G. water system are reluctant to pay for water service. The A.S.G. water system maintenance and operation staff is over-committed to the task of caring for the A.S.G. water system, and time spent with village systems is taken from the customers of the A.S.G. system.

The problem is not always clear cut or simple. In many villages, the A.S.G. has built schools, housing, dispensaries or offices. These facilities depend upon the village water system for their water supply, and the A.S.G. is obliged to make the repairs to the system necessary to provide service. Unfortunately, the systems are not adequately maintained, properly managed or constructed for sufficient capacity to meet demands. It becomes an impossible, never ending task to keep the systems operating just enough to provide water to the A.S.G. facility.

Past Improvement Programs

The A.S.G. has attempted wholesale improvements to the privately operated village water systems on several occasions. In the early 1960s, a cooperative improvement program to improve the village water system in the Leone area was attempted. Distribution lines and storage reservoirs were constructed throughout the villages of Leone, Puapua, Malaeloa, Taputimu and Vailoatai utilizing the stream catchment intake constructed by the military during WWII as the main supply source. The system has never operated correctly, and the storage reservoirs have deteriorated to a point of uselessness.

Leone Village receives the bulk of the water as it is closer to the source and lowest in elevation on the system while the upper villages receive water only periodically. The villagers report that because of cost overruns, the project was never completed properly and the A.S.G. did not live up to its end of the bargain. The system receives little or no management or maintenance.

In 1961, the A.S.G. completed projects near the villages of Asili in the Western District and Fagaitua in the Eastern District. Each of the projects interconnected villages in an attempt to more evenly distribute available water among the villages involved. Unfortunately, the A.S.G. did not discuss this concept with the villages before the systems were constructed. The villages with water were reluctant to give water to other villages without assurances that there would still be an ample supply remaining. The A.S.G. could not identify any group that was willing to assume responsibility for operation and maintenance of the systems. As a result, the systems are used very little and by default are maintained by the A.S.G.

In 1972, the A.S.G. received a grant from the Economic Development Administration for improvements to approximately 38 village water systems. The grant was obtained in response to the severe drought of 1971 which caused many hardships for the villages.

The success of this village water system program has been mixed. While some of the systems are operating satisfactorily, there are many which do not. There are several reasons for the problems:

1. The scope of each individual project was determined within the Public Works Department with little if any input from the villages concerned.
2. Because of the emergency situation, construction standards were reduced so that improvements could be made in as many villages as possible.
3. No provision was made for operation and maintenance of the systems.

The reduced construction standards were to have been offset by the fact that the systems were to become the property of the village in which they were constructed. Ownership by village could provide a degree of protection and careful use that would not be available in an A.S.G. run system. As an example of the required construction standards, distribution pipelines were not buried. As their contribution to the project, the villagers were advised to bury the pipelines.

Because the villages had little input into the planning and had no financial investment in the systems, they view the systems as belonging to the A.S.G. They feel that the responsibility for maintenance and protection of the systems also belongs to the A.S.G., and when the systems break down, they expect repairs to come from the A.S.G.

There is no operational control over the systems and no village organization with the technical capabilities or financial resources to repair the systems. When water is available, there is misuse and waste, and the systems which were designed to operate on a distribution storage principle fail because the storage tanks never fill. Sooner or later, the A.S.G. is obliged to undertake repairs, especially when the system serves a school, dispensary or other A.S.G. facility.

The problems associated with village systems become more acute with increasing populations, rising consumption and rising expectations for the quality of service.

WATER SYSTEMS MANAGEMENT

General

The existing public water supply system in American Samoa is a mixture of governmental (A.S.G.) systems and village systems. Historically, the management of these systems has been loosely structured, and management and operation decisions have been made without the benefit of policy guidance, objectives, or written procedures. The need to meet chronic water shortages and expediency in filling village desires has often overshadowed consistent management policy and has served to confuse the overall management of the territory's water systems. Recently, the A.S.G. began to define the management objectives of all A.S.G. water systems in the territory.

The purpose of this section is to describe the existing management of the water systems and recommended improvements. For the purpose of this study, water system management encompasses planning, design, operation, and maintenance.

The Management of the American Samoa Government Water Systems is the responsibility of the Department of Public Works (DPW). The current Department organization is shown on Figure V-2. Water system planning and design functions are the responsibility of the Water Systems Division (WSD), while operation and maintenance functions are the responsibility of the Water, Sewer, and Solid Waste Division (WSSW). In addition, the Director of Public Works has retained a consulting engineering company to specifically examine water system leakage and pump performance, and has formed special task forces for the installation of new distribution lines/booster pumps and water line inspection. These positive steps will greatly improve water system operation and management.

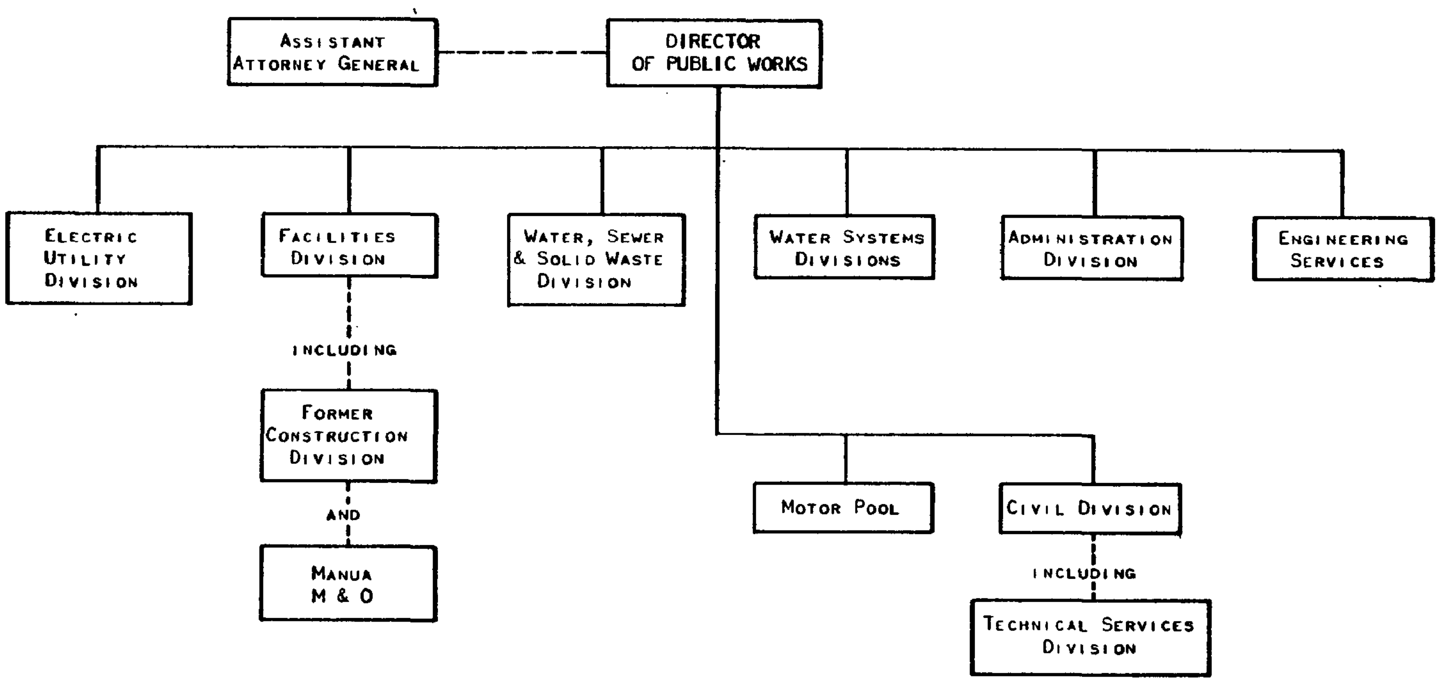
ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

FIGURE V-2

ORGANIZATION CHART

DEPARTMENT OF PUBLIC WORKS



The water system management functions within the Department are summarized on Figure V-3.

Planning and Design of water system facilities is the responsibility of the DPW Water Systems Division. Staffing consists of a division director and project engineers in charge of distribution systems, pump stations, and ground water. Other staff engineers and draftsmen from DPW are also available on an as-needed basis. Developed plans and specifications are reviewed with the water utility branch and equipment branch managers for operational considerations. Currently, the Division is primarily concerned with the design of the water system improvements in the existing capital improvement program (see Table V-5). There is no current Government of American Samoa planning or design effort underway for water system improvements beyond the 1981 construction program.

Operation and Maintenance of the A.S.G. water systems is the responsibility of the DPW Water, Sewer, and Solid Waste Division. The Division is officially divided into five branches: solid waste, sewer, water utility, equipment, and special projects. However, in 1977, the water utility and special projects branches were consolidated and simply called Water Utility. The emerging organization and the water system responsibilities of each branch of the Division are shown on Figure V-4.

Management Problems

Numerous problems in the planning and design as well as the operation and maintenance of the water system have been identified by several investigators, including WSSW and WSD administrators. Many of the administrative problems, such as a lack of formal paper flow through the Division, have been addressed by the existing management. Other identified problems are being addressed through increased attention to operations and an ambitious ongoing program of in-service training. Some of these identified problems, and current or recommended efforts aimed at solving them include:

FIGURE V-3

ORGANIZATION CHART

WATER SYSTEMS MANAGEMENT

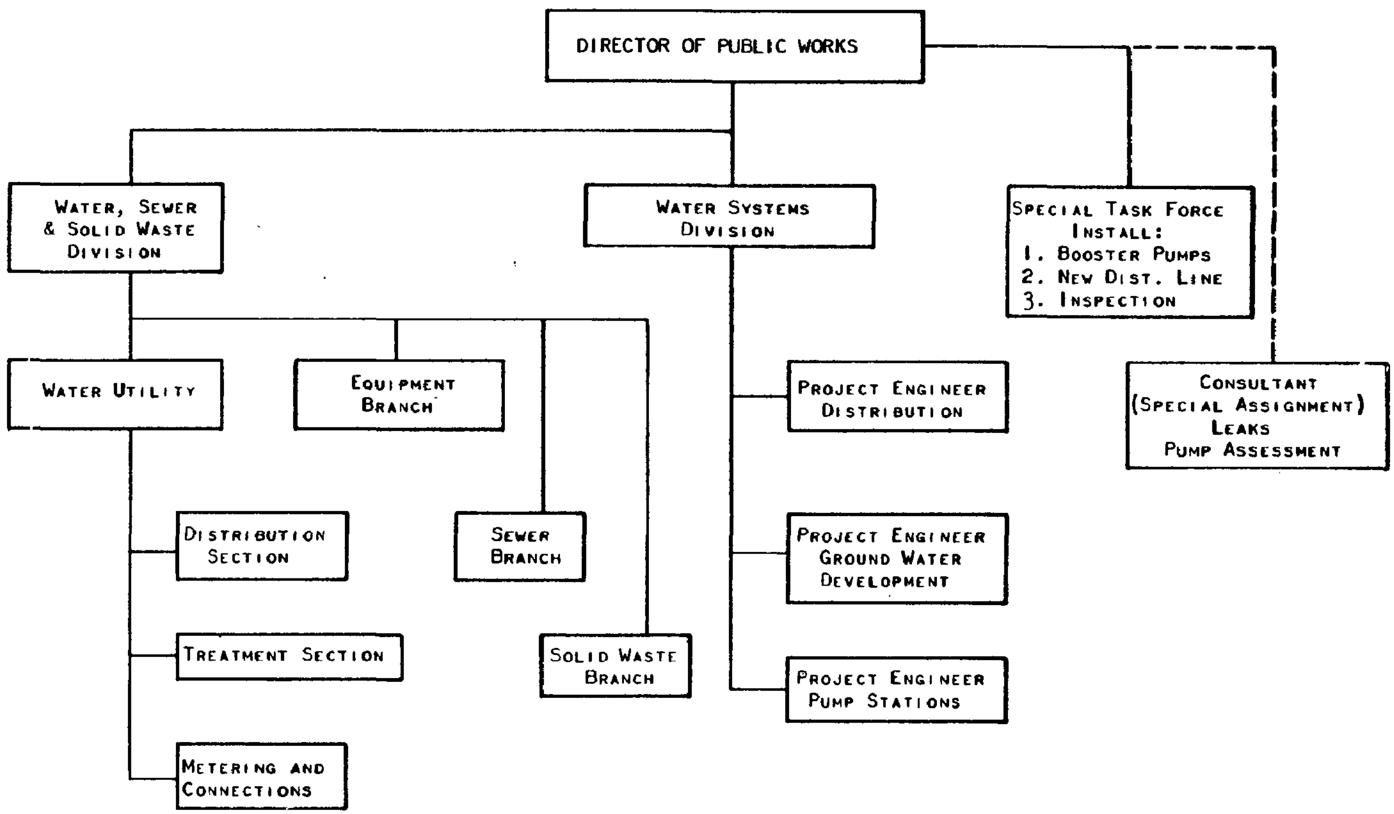
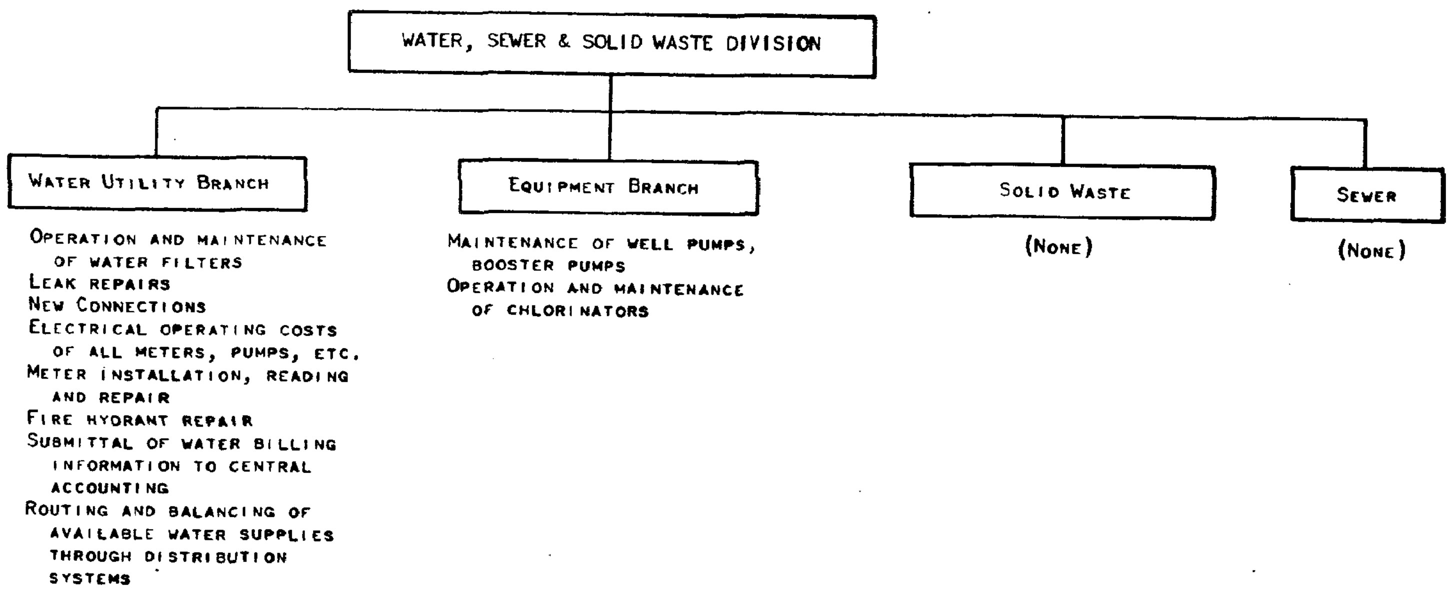


FIGURE V-4

WATER SYSTEM OPERATIONAL RESPONSIBILITIES



Identified Problem	Identified Solution
Inadequate communication within WSD causes a lack of knowledge about ultimate goals and individual roles in the program.	The division should hold regular staff meetings to improve communications between all concerned. A written plan should also be developed for continuity with changing contract engineers.
Objectives are not established for WSD and WSSW. Consequently, no mechanism exists for evaluation of employees or division accomplishment.	Specific and realistic objectives (reduce per capita consumption to 150 gpd, reduce delinquent water accounts to 10 percent, etc.) should be established and reviewed annually.
The WSD is too task oriented toward component installation, lacking sufficient consideration of total system operation.	DPW should increase operational input of WSSW into all projects. All new designs should delineate any changes in operating characteristics of the system.
There is a lack of total familiarity among employees throughout DPW to objectives.	Water Utility Branch objectives for FY 78 have been developed, written in both Samoan and English, and distributed to employees -- See Figure V-5.
Personnel lack necessary skills and judgmental knowledge of water system.	An in-service training program for foremen has been implemented to teach basic hydraulics, supervisory and mechanical skills. Highly trained employees are being hired as vacancies appear through attrition.

Identified Problem	Identified Solution
High turnover of employees in the Water Utility Branch occurs because of low salary levels.	All position descriptions are being examined, re-written as necessary, and salaries adjusted accordingly.
Management procedures in WSSW are vague.	The management manual for WSSW is being updated. Water utility regulations should be developed and adopted through A.S.G. administrative procedures.
High rate (approximately 30%) of water customers are delinquent in account payments due to discrepancies in consumption and billing.	Conflicts in meter readings and billings are being resolved and accuracy is improving in meter reading and billing preparation.
WSSW attempts to provide water service on request without evaluating capability or the effect on on operation and management resources.	WSSW should develop rules and regulations that will clearly delineate the manner of providing water service to customers.
"Free water" agreements in exchange for rights-of-way result in water waste and extension of free water to growing extended families.	DPW should identify households that receive free water under past agreements and limit this benefit to households existing at the time of agreement. A volume of water should be specified in any new agreements negotiated.

Identified Problem	Identified Solution
Lack of clear rights-of-way presents problem for maintenance and repair.	Insist that all facilities constructed that will be the maintenance responsibility of A.S.G. have an adequate and clear right of way.
No direct incentive exists for WSSW to meter or collect funds for water usage as funds collected are credited to the general account and not to the DPW budget.	If water system collections cannot be credited to WSSW account, include metering and collection of funds among the DPW Director's responsibilities.
Residential meter readings are inaccurate due to faulty meters. High level of suspended solids in water supply increases meter maintenance requirements.	Meter replacement/repair is receiving added emphasis, and water system filters have received additional attention. Suspended solids will be reduced as water quality is improved.
High leakage rate results in lack of service.	A special leak detection task force, under direction of a consulting engineer, is pinpointing leaks for repair. A new distribution system is being installed where replacement is more cost effective than repair.

Identified Problem	Identified Solution
Per capita water consumption rate appears high.	A.S.G. should increase water use charges. Water use should be metered at all service locations, billed and collections pursued as a means of encouraging water conservation. In addition, the government should repair leaks, detect and meter illegal connections, repair faulty meters, and improve accuracy of meter readings.
A.S.G. facilities, including employee housing, are not metered, possibly creating excess consumption and a double standard between the A.S.G. and the general public.	A.S.G. facilities should be metered and charged for water services (in the same manner as electrical services).
Improper repair equipment available to WSSW.	Equipment needs have been included in the FY 79 budget.
The inadequate water pressure provided to residents above service levels promotes water waste and backflow problems.	WSSW should develop policy of not allowing connections to A.S.G. system at elevations higher than 160 feet below storage reservoir overflow. WSSW should review building permits and ascertain that A.S.G. water can be provided at the proposed location. If service is not possible, A.S.G. should inform the applicant.

Identified Problem	Identified Solution
The legislature and general public have not been made fully aware of the need and components of a well managed water system. In addition, the operational procedures and improvement program of the A.S.G. water system have not been fully explained.	The DPW should develop a public education program under the auspices of the Safe Drinking Water Program that would educate the general public of the importance of a safe water supply that is adequate to meet demands consistently. The program should include a discussion of the functions of water meters, disadvantages and advantages of ground water versus surface water, rate structures, rules and regulations, objectives of the system as well as management, and future plans for the system.
No systems operations manual exists, and the water systems have not been mapped.	WSSW should prepare an operations manual and a map that shows the locations of all the water system components.

ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

FIGURE V-5

WATER UTILITY OBJECTIVES FY '78

DEPARTMENT OF PUBLIC WORKS

1. To provide every customer with safe potable water 24 hours per day. This potable water shall meet federal standards for chlorine residual, coliform level and turbidity.
2. To provide every service with at least 25 psi and at most 100 psi water pressure. To reduce the number of trouble calls due to low pressure or no water for any 3-month period to 60 or less (down from 700 in June-September 1977 period).
3. To be able to give 36 hours advance warning to customers of any scheduled water outage. To inform customers of every emergency water outage before customer complains to the Water Utility.
4. To be able to report accurately on a monthly and yearly basis water output from all A.S.G. sources and consumption at all metered taps. To be able to estimate unmetered water usage.
5. To reduce the percentage of unaccounted for water (due to unknown illegal connections and leaks) to 15 percent.
6. To provide in service training for all water personnel. Areas shall include water technology, basic hydraulics and quality plumbing and pipefitting practices.
7. To reduce the water accounts delinquency rate (2 months or more overdue) to 15 percent.
8. To meter all users including all GAS facilities connected to the water system.
9. To institute a more equitable rate structure which would recover all operating costs.
10. To stay within the budget plus or minus 5 percent each quarter.
11. To implement high quality plumbing and pipefitting practices.

Source: Department of Public Works
Water, Sewer, and Solid Waste Division
Water Utility Branch

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

WATER SOURCES

General

The findings of this engineering evaluation support the American Samoa Government's policy of utilizing ground water as the primary type of water source for its central water system. Existing information indicates that sufficient quantities of high quality ground water are available to meet year 2000 water demands for this system. The development of ground water supplies, however, must be carefully managed and monitored to insure that the safe yield of this valuable resource is not exceeded.

Surface water impoundments presently serving the central system should be maintained as emergency supplies and to supplement ground water sources. In most cases, existing surface sources should be phased out of operation as more ground water production wells are constructed.

Available hydrologic and geologic information and data pertinent to the development of water sources for individual village systems are generally insufficient. On-the-ground reconnaissance surveys of villages with water supply problems are needed to determine what type of water source development (i.e., surface or ground) should be pursued in each case.

Ground Water Development

Exploratory Well Drilling Program. The current A.S.G. exploratory well drilling program is directed at defining the ground water resources of American Samoa. The program can be divided by area into those activities that explore the Tafuna-Leone aquifer and those that explore small village aquifers.

An analysis of existing ground water data indicates that salt water intrusion is a constant threat at the Tafunafou well field and cautions against overdevelopment of the fresh water basal lens in this area (see Appendix B). It is recommended, therefore, that the ground water development program be directed to other areas in and around the Tafuna-Leone plain.

The wide and deep Malaeimi and Malaeloa valleys appear to be promising as supplemental sources of ground water for the A.S.G. system and deserve to be explored. They are both relatively large basins; they are situated landward of the Tafuna-Leone Plain; thus, farther from the coastline and generally above the more populated areas (i.e., potential sources of ground water contamination); and they may be substantial sources of recharge for the Tafuna-Leone aquifer.

The exploratory well drilling program should also attempt to delineate the limits of the Tafuna-Leone aquifer to provide direction for its future development and to aid in a reliable estimate of its safe yield potential.

The investigation of other small village aquifers should be directed toward those villages which have the most critical water supply problems and which are not planned to become a part of the A.S.G. centralized water system.

The Manua Islands villages are completely dependent upon ground water for supply as there are no reliable alternative sources readily available. Fitiuta Village has the most critical current supply problem.

Exploratory wells should be drilled on the ridge behind the village as far from the shoreline as possible. If sufficient quantities of ground water are encountered, two wells should be completed and fitted with pumps of sufficient capacity to individually supply the village. The wells and pumps will represent a sizeable investment by the A.S.G. and should be operated and maintained by the A.S.G.

Tau and Faleasao Villages require an additional well to supplement the existing drilled well at Luma High School.

Ofu and Olosega Villages require additional wells to increase capacity and provide reliability to those systems. The Olosega well should include capacity for Sili Village. Each of these wells can be hand dug or drilled depending upon the availability of the drilling equipment, the logistics of shipping, and the availability of labor.

After completion of the Manua Islands program, the exploratory program should concentrate on the villages of the southeast shore of Tutuila from Auto to Tula. These villages have the most critical water supply problem on Tutuila Island, since few of the streams in the area are perennial. A priority system listing such factors as: ground water potential, A.S.G. facilities to be served, population and absence of other developed resources should be compiled to provide a schedule for an exploratory program. Table VI-1 shows a suggested ranking for these villages of the southeast shore.

Production Well Construction. The construction of efficient and permanent water wells involves two separate and distinct operations: the mechanical aspects of drilling a hole in the ground and technical supervision, which includes the engineering and design of the well to fit the particular hydrology and geology of subsurface conditions at each individual well site. In the past 20 years, more than 60 holes have

TABLE VI-1

SUGGESTED VILLAGE RANKING FOR EXPLORATORY WELLS SOUTHEAST SHORE OF TUTUILA

Village Name	Ground Water Potential Ranking [1]	Critical A.S.G. Facilities to be Served Ranking [1]	Population Ranking [1]	Absence of Other Resource Ranking [1]	Total	Overall Ranking [1]
Auto	8	4 [2]	6	8	26	8
Amaua	9	4 [2]	8	6	27	9
Fagaitua	2	1	1	5	9	2
Alofau	3	3	2	1	9	1
Amouli	5	2	4	4	15	5
Auasi	7	4 [2]	7	3	21	6
Utumea	6	4 [2]	9	3 [3]	22	7
Alao	4	4 [2]	5	2	15	4
Tula	1	3	3	7	14	3

[1] Rankings indicate which village has the highest priority for each factor. Lowest number indicates highest priority.

[2] Contain no A.S.G. facilities.

[3] Served by Ausi water system.

been drilled on Tutuila without the benefit of technical supervision. As a consequence, not enough is known about their construction other than the location, depth and, in some cases, quality of water. The quality and quantity of water from these holes, especially in the Tafuna-Leone plain, are directly related to the uncontrolled manner in which they were constructed.

The A.S.G. Public Works Department recently (in May 1978) acquired the services of an experienced hydrogeologist and a well driller. In view of past well construction problems, the results of this study strongly encourage maintaining this level of technical expertise in the future.

Ground Water Contamination. The importance of protecting potable ground water supplies from all sources of contamination cannot be overemphasized. Once contaminated, the integrity of ground water supplies is difficult to restore. Treatment, as is the case with surface water, is expensive, and the economic advantage of having good natural quality ground water is lost.

Since drilling penetrates the surface soil (overburden) above ground water sources, all drilled holes must also be viewed as potential pipelines for introducing contaminants into subsurface supplies, and precautionary measures must be taken at each hole. For this reason, it is recommended that a program be instituted to seal abandoned and unsealed drilled holes and wells and to insure that production and observation wells in use have adequate sanitary seals.

As a general guideline, one of the first considerations that should be given in ground water development is to select favorable production well sites that are above, or upstream, of anticipated sources of contamination. Ground water under unconfined or water table conditions, like surface water, flows by gravity. Achieving this advantage reduces the need to impose strict land use controls in tributary areas.

Over the long-term, the protection of ground water supplies mandates the strict coordination of waste collection and disposal (wastewater and solid waste) and land use practices and plans with those of ground water development.

Surface Waters

The short-term operation (next 20 years) of the existing surface water treatment facilities at Fagaalu, Fagatogo and Pago Pago should be used for emergency supplies and to serve the upper elevations of those villages only until the A.S.G. ground water sources and water delivery system is reliably capable of supplying water to the Bay Area (Pago Pago).

The existing filtration equipment should be maintained in an operable condition. Expenditures on the treatment equipment should be kept to a minimum and efforts at major upgrading of the equipment should not be undertaken at the expense of improvements to the primary ground water source.

The following is a list by sources of general recommendations for the short-term disposition of the surface water sources:

1. Puna Dam and Intake
   Abandon as soon as the proposed transmission and booster system that will supply ground water from Tafuna to Mapusagafou is complete. Recommended interim, temporary improvements to make the water safe for residents that are now served by the source include installation of chlorination equipment and repair of the 90,000 gallon Mapusagafou tank.

2. Vaitele Dam and Intake

Abandon as soon as adequate and reliable supplies are available from the Tafuna wells. This should occur in the very near future as there are four existing wells awaiting installation of pumps and four new wells contracted for drilling.

3. Fagaalu Intake

Discontinue regular use of this supply as soon as adequate and reliable ground water supplies from Tafuna are available in the Bay Area. The existing transmission system as it exists is adequate for this purpose, however, as described in Chapter V, excessive demands on the system have created flow rates beyond the system capacity. The reduction or elimination of the excessive demands as described later in this chapter will allow abandonment of this source.

Temporary rehabilitation of the facilities will be necessary as it is anticipated that it will be at least five years before the excessive demands will be reduced. Rehabilitation work should include repair and recharging the filters and installation of a more positive chlorination system.

4. Fagatogo Reservoir and Upper Fagaalu Intake

Discontinue use as a regular source of supply to the lower Bay Area service level of the A.S.G. system as soon as adequate and reliable ground water supplies from Tafuna are available in the Bay Area. This source may be kept operational to serve residences above the upper service limit of the Bay Area lower service level. Longer term planning should include a booster station to lift water from the lower service level to a properly designed higher service level distribution system.

Temporary rehabilitation of the treatment facilities is required and should include repair and recharging of the filters and installation of a more positive chlorination system.

5. Vaipito Intake

   This source has the most protected and highest quality water of all the existing surface water sources. With proper management and operation of the existing facilities, it may be able to supply the upper elevations of Pago Pago Village for the foreseeable future.

   The immediate improvements required to this source include control of the watershed to prevent contamination, diversion of overland flow away from the Vaipito Reservoir, testing, and if necessary, repair of the basin for leaks, repair of the filters, and installation of positive chlorination equipment. This system will also require a review and modification of current operating procedures and competent operator attention to bypass unsuitable water and to insure that the equipment is operating correctly.

   Longer term improvements should include a new upper service level finished water distribution reservoir to serve the upper service level and booster pumps at the filters and at the lower service level to lift water to the new upper service level distribution storage reservoir.

The long-term operation of existing surface water sources and development of new surface water sources is dependent upon more extensive information and experience with the ground water sources. If supplemental surface water supplies must be developed, the existing surface water sources must be the first to be reevaluated. The decision will be made based upon conditions that exist at that time.

It is difficult, if not impossible, to determine the conditions that will govern this decision. It seems reasonable to assume that an objective will be to combine the best sources for treatment at a central point(s). Based upon this, we would anticipate that the upper and lower Fagaalu sources would be combined for treatment at Fagaalu and the Fagatogo treatment facilities abandoned. The Vaipito intake and treatment facilities would be upgraded and utilized for the upper service levels of Pago Pago Village.

Development of new surface water supplies to supplement the ground water aquifer will be dependent upon the same future conditions, economics being one of the most important. If new surface water sources are to be developed, one of the important criteria for selection of the source should be the relative location to the ground water supplies.

The existing ground water supplies are located in a relatively centralized area, and water is transported from there along a lineal pipeline system to the ends of the service area. A break in a pipeline could discontinue service to large areas. Development of a surface water source at a location near the end of the service area could improve the reliability of the system and extend the life of the transmission system by providing additional capacity.

With this criteria in mind, the most ideal location for a surface water source would be in the eastern district. The perennial streams radiating from Pioa Mountain (Rainmaker) have the best potential. Of these, Alega stream and the Maga, Lesea and Vaitele stream complex above Laulii Village have the best location as they are on the south shore of the island. Investigations (Dames and Moore, 1978) of the Laulii Village stream complex indicate that a sustained regulated flow of 1.8 million gallons per day could be developed. This flow rate would be adequate to supply the year 2000 water demands for the south east shore of Tutuila Island, but it would require a dam of approximately 180 feet in height to develop this flow. The economics of constructing a dam of this magnitude in Samoa are very questionable. The A.S.G. should monitor flow rates in key streams to aid in future feasibility studies. Consideration should also be given to protection of the watersheds of certain key streams so that they will be available for development in the future.

TRANSMISSION AND PUMPING SYSTEM

General

The recommended transmission system is shown in Figures VI-11, VI-12 and VI-13. The past emphasis of the capital improvement program toward transmission pipelines has created a transmission system that is adequate to serve the existing A.S.G. water service area until approximately 1990. The projected A.S.G. system flow rates and calculated hydraulic grade line for the year 2000 are shown in Tables VI-2 and VI-3.

Completion of Existing System

Prior to 1990, improvements will have to be made to the pipeline sections between Nuuuli and Fagaalu and between Utulei Village and Malaloa. An alternate alignment for the Utulei - Malaloa pipeline that would cross under the harbor near the oil dock is available. This alternate deserves detailed study as it would eliminate the need for new pipeline construction through the congested Fagatogo area, eliminate the need for the Pago Pago pump station, reduce the required pipe size between Atuu and Aua and provide a more flexible looping water system. The cross bay alternate would present some severe construction difficulties as the 2500 foot crossing would be in water up to 150 feet deep and the area is used for ship achorage.

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TABLE VI-2

PEAK YEAR 2000 FLOW RATES

FOR A.S.G. WATER SYSTEM

Service Area	Year 2000[1] Population	Industrial Demand (MGD)	Residential[2] Demand (MGD)	Total Flow (MGD)	Cummulative Flow (MGD)
Tafuna & Vaitogi	3779	0.25	0.850	1.100	7.601
Nuuuli	5527	-	1.244	1.244	6.501
Faganeanea to Fatumafuti	786	-	0.177	0.177	5.257
Fagaalu	1533	0.07	0.345	0.415	5.080
Utulei	1529	0.06	0.344	0.404	4.665
Fagatogo	2917	0.07	0.656	0.726	4.261
Pago Pago	4126	0.80	0.928	1.728	3.535
Anua to Aua	3674	0.10	0.827	0.927	1.807
Tafananai to Laulii	797	-	0.179	0.179	0.880
Alega to Avaio	88	-	0.020	0.020	0.701
Auto to Fagaitua	929	0.05	0.209	0.259	0.681
Alofau	496	-	0.112	0.112	0.422
Amouli to Tula	1377	-	0.310	0.310	0.310

1 Per A.S.G. Development and Planning Office.

2 Population x 150 GPCD x 1.5 peak day factor.

3 Assumes no surface water inflow to system.

TABLE VI-3

HYDRAULIC GRADE LINE FOR A.S.G. WATER SYSTEM YEAR 2000 PEAK DAY FLOW

Location	Flow Rate MGD	Flow Rate GPM	Pipe Size (in)	Head loss ft/1000 ft	Length (ft)	Head loss (ft)	Elevation HGL
Highway near well field							260
	7.601	5278	20	5.4	2500	13.5	
Highway at Airport Road							247
	6.000	4167	24	1.3	2500	3.3	
Highway at Housing Road							243
	5.400	3750	24	1.0	7500	7.5	
Highway at Coconut Point							236
	5.257	3651	20	2.6	12,000	30.8	
Fagaalu							201 to 255
	5.080	3528	20	2.7	7500	20	
Utulei							235
	4.665	3240	20	2.3	4000	9	
Magaalii							224
	4.261	2959	20	2.0	4200	8	
Malaloa							216
	3.535	2455	16	4.1	1500	6	
Pago Booster							210 to 255
	2.607	1810	12	11.5	4000	46	
Pago Pago							246
	2.607	1810	12	11.5	4000	46	
Canneries							200
	1.807	1255	16	0.91	10,000	9	
Aua							191 to 255
	0.880	600	12	1.2	13,000	16	
Laulii							239
	0.701	490	12	0.89	4500	4	
Alega							235
	0.681	470	12	0.89	12,000	11	
Auto							224
	0.422	300	8	2.5	4000	10	
Alofau Booster							214 to 320
	0.310	215	8	1.5	7000	11	
Amouli							309 to 230
	0.310	215	8	1.5	18,000	27	
Tula							203

The above statements are made on the premise that water consumption can be reduced to a more reasonable 150 gallons per capita per day as discussed in the Distribution System recommendations. Without this reduction in consumption, the two pipeline improvements from Nuuuli to Fagaalu and Utulei to Malaloa are required immediately.

Two other small projects within the existing A.S.G. water system service area are the airport extension to improve service to the airport and the 12-inch pipeline from the Pago Pago Reservoir Road to Siufuga. Each of these two projects will enable the abandonment of an old troublesome pipeline.

Extension of System

The recommended program also includes extension of the A.S.G. system eastward from Aua Village to Tula Village at the far eastern tip of the island, westward from Futiga to Amanave at the far western tip of the island and up from Mapusagafou to Aoloaufou Village at the top of the mountain ridge.

The recommendation for this expansion is based upon the assumption that this is in the best interests of residents concerned and that they desire to be served by the A.S.G. water system. Before any of the expansion to the service of the A.S.G. water system is begun, several items should be resolved:

1. The A.S.G. should improve the reliability of the existing system to provide sufficient quantities of high quality water, and in doing so, improve its public image as being capable of providing this service.
2. Conduct a public education program to inform the public of the managerial, public health, and safety aspects of the operation of water systems. Subjects covered should include such

items as: 1) Need for disinfection, 2) The reasons why metering is required, and 3) The advantages and disadvantages of ground water versus surface water sources.

3. Insure that sufficient water supplies, transmission facilities and maintenance capabilities are available to support the new expanded service area.
4. Ascertain that the villages involved wish to have an A.S.G. water system and are willing to allow the degree of control over the water system that is required for proper operation of the water system. As a minimum, the villagers should be willing to pay for water at the prevailing metered rate, donate or sell to the A.S.G. the required land area necessary to construct the water system facilities, and donate or sell any existing privately owned water system facilities that will be incorporated into the new A.S.G. water system.

The A.S.G is proposing to make improvements to the Leone water system in the near future. The A.S.G. has drilled and is operating two wells on the grounds of the Catholic Boys School at Malaeloa in an attempt to supply water to the two private Catholic schools and to the A.S.G. facilities at Leone. The privately operated Leone water system has been unable or unwilling to upgrade its system to meet rising demands for water and has forced the A.S.G. to step in and provide the additional water supplies without charge.

In addition to the wells, the A.S.G. is currently designing the Western Loop pipeline project which will distribute water throughout the Leone area. The A.S.G. should be extremely careful in the design of this project to maintain control over these new pipelines and avoid connecting into the existing distribution system unless it is upgraded and all existing services are metered.

The residents of the Leone area should be kept thoroughly informed and their concerns should be reflected in the design of the water system. The project should not continue into the construction stage unless there is agreement between the residents and the A.S.G. on the design concepts and the future operation and management of the system. Some of the points that need to be clarified include:

1. Will the A.S.G. or the villages be responsible for maintenance and operation of the new system?
2. What portions of the existing Leone water system will be incorporated into the new system?
3. Will the water services be metered?
4. How will the existing surface water sources at Leone and Malaeloa be incorporated into the new system?
5. If the A.S.G. is going to operate and manage the system, what rights will they have over the incorporated portions of the existing system and the existing surface water sources?

Booster Stations

The Aua and Alofau Booster Pumping Stations will be required when the water transmission system is expanded easterly beyond Aua Village. With the indicated sizes on the new pipelines, these booster stations will be able to supply water to Tula Village on the east end of the island. The Alofau booster station is required to lift water above and beyond the high elevation roadway at Cape Fogausa.

The Iliili booster station should be sized with sufficient capacity and head to lift water to the Futiga reservoir for service to Futiga, Pavaiai, Iliili, the Leone Plain villages, and the villages from Leone to Amanave. This pump station can serve as a backup supply to the Malaeloa well field.

The Futiga booster station will be used to lift water from the second service level Futiga Reservoir to the third level Mapusagafou #1 Reservoir. The pumps should have sufficient capacity to serve Futiga, Pavaiai, Mapusagafou, Mapusaga and Aoloaufou villages. This booster station will serve as a backup to the Pavaiai and Mapusaga (A.S.C.C.) booster stations.

The Mapusaga (A.S.C.C.) booster station should be sized to lift water to the Pavaiai Reservoir and should have sufficient capacity to serve the villages of Mapusaga, Pavaiai, Futiga, Mapusagafou and Aoloaufou.

The Pavaiai booster station should lift water the next step into service level three and supply the villages of Futiga, Pavaiai, Mapusagafou and Aoloaufou.

The Mapusagafou pump stations numbers one through four should be sized to progressively lift the required amount of water from service level three to service level seven.

The Malaeloa well pumps will lift water directly to the second service level Futiga Reservoir. Water can be dropped from this reservoir to Amanave at the western tip of the island and can also be used to supplement the Tafunafou well field.

Residences in Fagatogo and Pago Pago villages are being constructed at an elevation that requires the creation of a second service level in these villages. When the distribution system is rehabilitated in these villages, provisions for the second level and for the booster pumps should be provided.

STORAGE

General

The functions of a water system storage facilities are to:

1. Meet peak demand rates.
2. Supply fire fighting requirements.
3. Provide operational flexibility.
4. Provide pressure and flow equalization.
5. Provide system reliability.

The only quantitative functions are those relating to peak and fire demands. The other functions are equally important, but are more characteristic of the management and operation of each system.

The recommended additional storage capacity required to meet the year 2000 demands is shown in Table VI-4. The requirements were determined according to the design criteria developed in Chapter IV and included capacity for peak hour flow reserve and fire reserves.

In order to maintain system pressure and flow requirements during periods of peak water use, elevated storage should be located in the areas having the lowest system pressures during intervals of high water use. These areas are usually those of greatest water demand or those most remote from pump stations. Elevated tanks are generally located at some distance from pump stations serving the same distribution pressure level, but not outside the boundaries of the service area unless the facility can be placed on a hill near the service area.

Additional considerations for siting of elevated storage are terrain conditions, suitability of subsurface and/or rock for foundation purposes, and hazards of low-flying aircraft, especially near airports. Elevated

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TABLE VI-4

RECOMMENDED ADDITIONAL STORAGE CAPACITY

Reservoir Names	Service Area	Existing Storage Capacity (MG)	Total[1] Recom. Storage Capacity (MG)	Recom. New Reservoir (MG)
Amanave	Amanave, Failolo	-	0.75	0.50[5]
Autauloma	Seetaga to Asili	-	-	0.50
Taputimu	Leone, Vailoatai, Taputimu	-	1.5	1.5
Futiga	Futiga, Pavaiai, Iliili, Malaeloa, Puapua	-	0.25	2.5[2]
Mapusagafou #1	Mapusagafou	-	1.0	1.0
Mapusagafou #2	Mapusagafou	-	0.25	0.25
Mapusagafou #3	Mapusagafou	-	0.25	0.25
Mapusagafou #4	Mapusagafou	-	0.25	0.25
Iliili	-	-	0.50	-[3]
Vaitogi	Vaitogi, Tafuna, Nuuuli	-	0.50	1.5
Tafuna	Vaitogi, Tafuna, Nuuuli	0.50	2.0	2.0[4]
Pavaiai	Mapusaga	0.75	0.75	-
Blunts Point, Maugaalii	Fagaalu, Utulei	2.0	2.0	-
Pago Pago, Atuu, Aua	Pago Pago to Aua	2.0	3.0	1.0
Laulii	Laulii to Alega	-	0.25	0.25
Fagaitua	Auto to Utumea	-	0.50	0.50
Leva Point	Amouli to Utumea	-	0.50	0.50
Tula	Tula, Alao	-	-	0.25[5]
	TOTAL	5.25	14.25	12.75

[1] From Table IV-8.

[2] Provide approximately one day storage reserve for gravity supplyto all villages west of Futiga in power outage or other emergency.

[3] Service provided from Futiga Reservoir, separate reservoir not required.

[4] Serve booster stations to Bay Area and potential high demand Tafuna-Nuuuli area provide 1.5 MG reserve storage for operational feasibility.

[5] Provide added storage at end of line.

tanks are normally built on the highest available ground so as to minimize the required construction heights.

The majority of the reservoir capacities and locations require no special comments as to their size and location as the data is directly from the criteria. The tank locations shown are approximate. Generally, the tanks can be moved around within their service area to a site that presents the least obstacles as far as physical construction, right-of-way, cultural, or environmental concerns.

Reservoir Location and Capacities

The Aua Reservoir is shown at base elevation 175 feet because that is the way it has been previously designed. Right-of-way for the reservoir has been obtained and construction is planned for the very near future. By setting the reservoir at an elevation lower than the standard 190 feet, the flexibility for future changes in the water system and efficiency of use of stored water is greatly reduced. Consideration should be given to redesigning this tank for a base elevation of 190 feet above sea level.

The Tafuna, Nuuuli and Vaitogi service area storage requirement has been divided into two separate reservoirs, one near the Malaeimi well field (Tafuna Reservoir) and one near Iliili Village (Vaitogi Reservoir). The Vaitogi Reservoir storage capacity at the far end of the service level from the Tafuna well field source will provide better pressure distribution at peak hour flows and will facilitate using the airport/ Iliili pipeline for backup transfer of water to Leone. The Vaitogi tank site will also provide an easier site for tank construction, but will require an added connecting pipeline. An additional 1.5 million gallons of storage capacity has been added to the volume called for in the criteria to provide operational flexibility and system reliability.

The Tafuna-Nuuuli area has a high potential for development and will require significant volumes of water. Water stored in this service level provides the source supply for the entire system to the east. The added volume will provide a reserve for short-term loss of supply from the Tafunafou wells.

The Futiga Reservoir has been located and sized to supply the villages of Malaeloa, Puapua and Iliili. Added capacity has been provided for operational flexibility and system reliability. With the indicated 2.5 million gallons of storage, the reservoir can supply by gravity approximately one day's demand to all villages west of Futiga. The water would also be available by gravity to the Vaitogi, Tafuna and Nuuuli area.

The Futiga Reservoir would be supplied primarily from the wells at Malaeloa. Discharge pressures on the well pumps should be designed for direct supply to the reservoir. The reservoir can also be supplied with water from the Tafunafou well field by the Iliili booster station or more indirectly by lifting water at the Mapusaga (A.S.C.C.) and Pavaiai booster stations and then dropping back down at the Futiga pressure reducing valve.

The Leone service level will be supplied from storage in the Taputimu reservoir. The Taputimu location is recommended over a previously considered site near Leone because the Taputimu site is superior from an ease of construction viewpoint. The Leone site is somewhat better functionally because it is closer to the Leone population center, but either site would be acceptable.

TREATMENT

General

The treatment of existing and proposed A.S.G. water system supplies can be divided into two general areas, existing surface water supplies and existing and new ground water supplies.

Existing Surface Water Supplies

The treatment of the existing surface water supplies at Puna Dam, Fagaalu, Fagatogo and Pago Pago should be rehabilitated as described in the previous section on "Surface Water" in this chapter. Generally, the rehabilitation should consist of installation of more positive disinfection systems (chlorination) and repairs to the filters.

Existing Ground Water Supplies

The treatment of the existing ground water supplies should be upgraded as described in the report Disinfection of Ground Water Supplies, CH2M-Hill, 1977. Each of the production wells should be provided with chlorination equipment, and in addition, to insure that a chlorine residual is maintained in the Bay Area, a chlorine monitoring station with re-chlorination capabilities should be installed on the system somewhere between Nuuuli and Fagaalu. A suggested possible site is at the Nuuuli booster station which has been programmed to be abandoned.

New Ground Water Supplies

The recommended new ground water sources at Tafuna and Malaeloa should be disinfected with chlorine at a central point at each site.

DISTRIBUTION SYSTEM

General

As discussed in previous sections, the distribution system is the weak link in the existing water system. Residential consumption averaging 285 gallons per capita per day has been estimated in the existing services. This high consumption is due primarily to leakage and waste in unmetered and illegal connections. The excess water consumption is such a burden on the existing transmission, pumping and storage facilities that the system will not operate correctly.

In many areas, the existing distribution system is a tangle of small diameter pipelines that branch off of the main transmission pipelines into the community. Distribution pipelines wander throughout villages above and underground and it is difficult to determine which lines are metered and which are not. Illegal connections are simple to make and difficult to police. Repairs to pipelines are sometimes difficult as no rights-of-way exist for most distribution pipelines. Residents can insist at any time that distribution pipelines be removed from their property or prohibit meter readers or repair personnel from having access to their property. Meters are placed everywhere, in and under homes, outside on the ground surface and underground. The meters are difficult to locate, to read and to repair, and it is sometimes nearly impossible to relate a specific meter to any given house.

The A.S.G. should immediately begin an extensive five to ten year program to completely rehabilitate the existing A.S.G. distribution system. To be successful, the program needs support from the Governor's office and the Legislature ("Fono"). Initially, the program will not be popular. If the importance of the program is communicated and results in the form of improved water services are demonstrated, then subsequent efforts will be made easier. Overcoming the initial public resistance will be the first and a major problem faced by the program. A comprehensive public education and public information program will be required.

The completion of the program in the five to ten years projected will require all the resources of the Water System Division and support from the Water, Sewer and Solid Waste Division personnel.

REHABILITATION PROGRAM

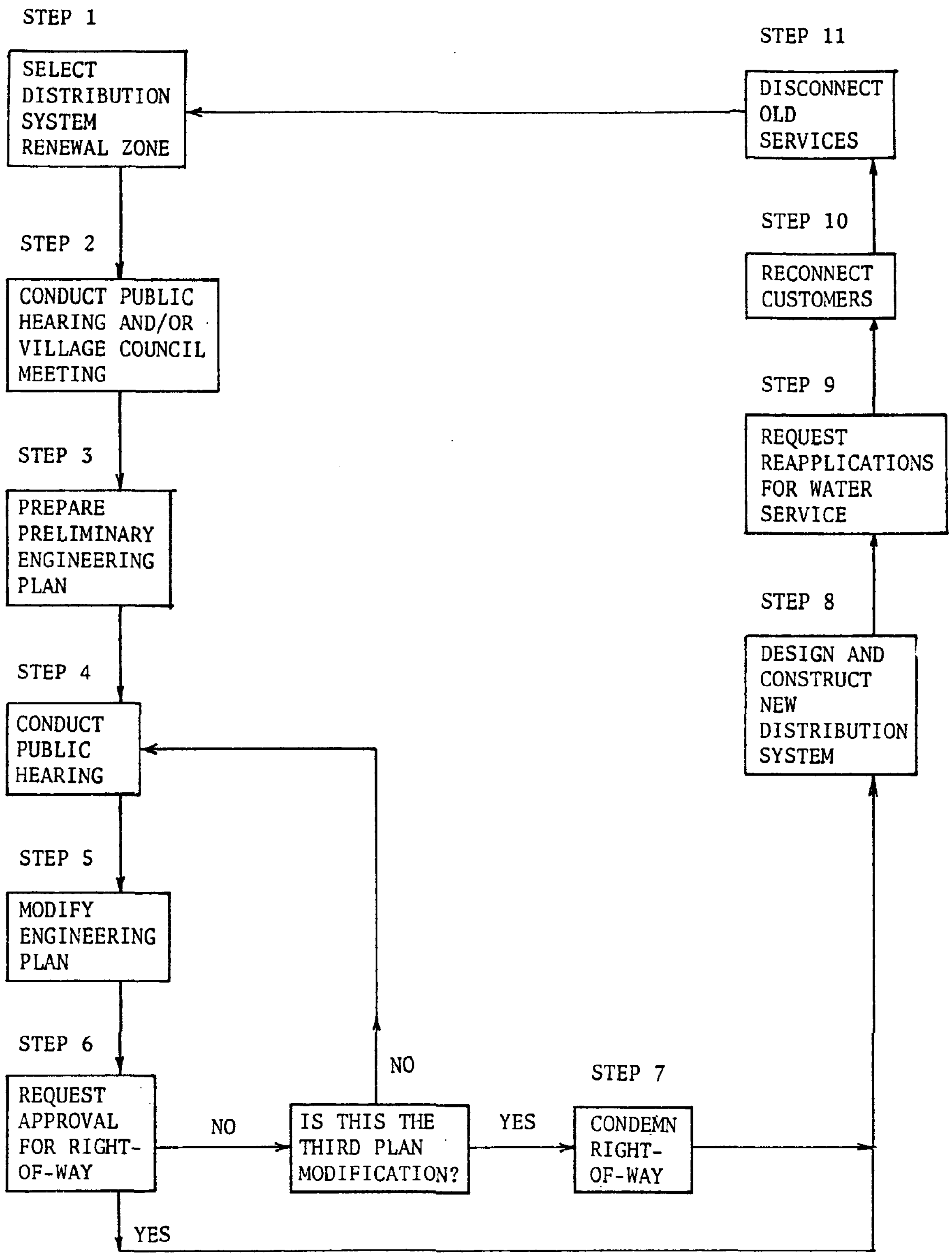
The objectives of the rehabilitation program are as follows:

1. To reduce water waste and misuse
2. To facilitate water system maintenance and repair
3. To reduce operating costs
4. To provide better fire protection
5. To provide equitable water use charges to all water system customers
6. To ensure that all consumers are metered
7. To facilitate meter reading
8. To increase revenues

The program outline is shown on Figure VI-1 and is described in more detail as follows:

Step 1. Systematically divide the A.S.G. water system into zones of approximately 50 houses (or any other number that is manageable) that are contiguous and that physically and culturally lend themselves to water distribution improvements.

FIGURE VI-1
**DISTRIBUTION SYSTEM
REHABILITATION PROGRAM OUTLINE**



Step 2. Conduct a public hearing and/or a village council meeting to present the distribution system rehabilitation program and its objectives, request community support, discuss the water service agreement form and obtain community input.

Step 3. Prepare a preliminary engineering plan for the Water Distribution improvements in the zone. The preliminary plan would attempt to provide water service to the zone through existing A.S.G. easements or recognized public rights-of-way that can be converted to pipeline easements.

The preliminary plan would provide fire protection to the zone by maintaining a minimum 6-inch diameter pipeline size and providing adequately spaced fire hydrants. The preliminary plan would provide for right-of-way for all A.S.G. maintained water system facilities for repair and meter reading.

Step 4. Conduct a public hearing to present the preliminary engineering plan to the residents of the zone and to hear criticisms and suggestions for the proposed plan.

Step 5. Modify the plan as required and as practicable to reflect public comments.

Step 6. Conduct up to two additional public hearings to present the revised preliminary plan to collect and include public suggestions and request right-of-way for the improvement facilities.

Step 7. If right-of-way has not been negotiated at the end of a designated period (60 days after last public hearing) proceed with condemnation for the pipeline right-of-way.

Step 8. When proper right-of-way has been obtained, construct new distribution pipeline.

Step 9. Request that all residents (existing and new customers) who wish to obtain water service apply at the Department of Public Works.

Step 10. Connect the services to the new main pipeline. All new meters shall be within the right-of-way and as close to the main pipeline as possible. The new meters shall be installed with sufficient fittings to prevent backflow and to allow quick removal of the meter for repair or for discontinuance of service.

Meters would be installed within a meter box to protect them from damage or vandalism.

When reconnecting existing customers, adequate service pipe of proper size would be provided by the A.S.G. so that service will reach the point of the original service meter or the residence. It will be the responsibility of the customer to obtain right-of-way for his service lateral.

Service to all new customers shall be at the nearest distribution main.

Step 11. Disconnect all the old existing service connections from the main pipeline.

Step 12. Continue with next zone.

VILLAGE WATER SYSTEMS

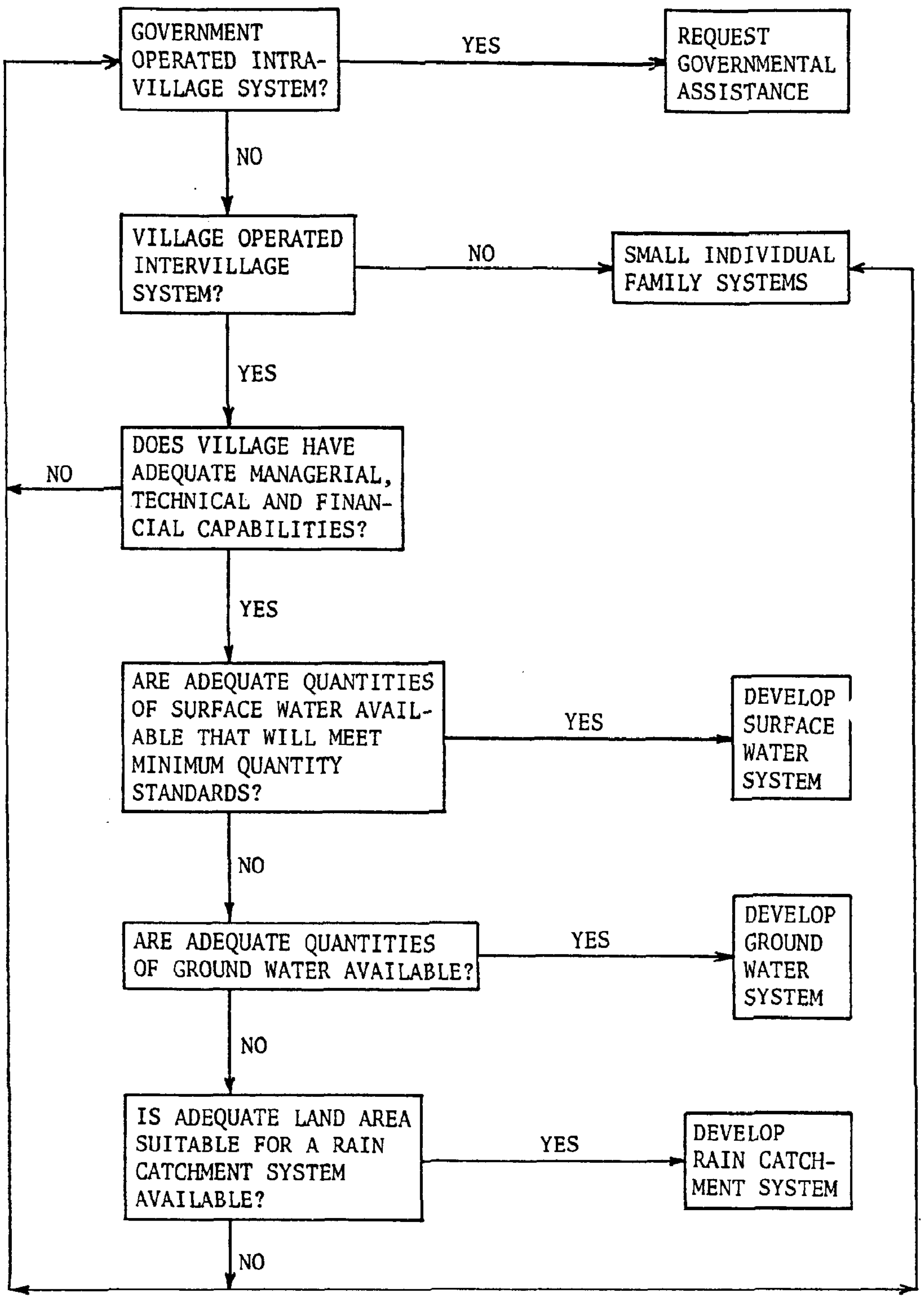
General

Within the constraints of Public Health Requirements (See Malae, 1976), most individual villages or individuals will be free to either request water service from the A.S.G. system or to develop and operate their own water systems. The choices opened to the villages are illustrated in Decision Diagram (Figure VI-2).

ASSESSMENT OF WATER SYSTEMS
AMERICAN SAMOA

FIGURE VI-2

VILLAGE WATER SYSTEM DECISION DIAGRAM



If there is a choice and if the villages wish to remain independent from the A.S.G water system and feel that they have the managerial, technical, and financial resources required to properly operate a water system within existing federal law, they should investigate the water resources within the village. On the basis that the source that is least expensive to develop is the source that should be investigated first - surface water, ground water and rainshed catchment systems should be investigated in that respective order.

If none of these sources are viable, then the village should look again at the A.S.G. system, at individual home roof catchment systems, or other individual systems.

Whenever the A.S.G. participates in the development or improvement of a water system within an isolated village or villages, the village(s) should be given the option of operating and maintaining that system. The village should understand that it will assume all responsibilities for the operations including financial and legal obligations.

The most important legal obligation at this time is PL 93-523. This law applies to all public water supplies having at least 15 service connections or serving 25 or more people. The law requires that tests be regularly conducted to determine if the water supply complies with the minimum requirements. Public notice must be given of any failure to meet standards. The Environmental Protection Agency, the Territory, or private citizens may take legal action against any village believed to be in violation of the act. Copies of the Act, together with a written summary in both Samoan and English, should be given to villages operating systems.

All operational and maintenance expenses should be borne by the village. It is highly inconsistent and unfair for consumers on the A.S.G. water system to be charged for water while villages receive free water and free water system repair service. The basis and reasoning for charging for water service is that the A.S.G. will then operate and maintain the water system.

Experience with developing village water systems in many countries (World Bank 1976 and Civil Engineering 1978) indicates that it is highly desirable that the village be involved in the entire system planning process and the village contributes toward the improvements. Most villages in American Samoa want to contribute labor rather than financial support.

The contribution of labor is an acceptable alternate, but it creates several construction management problems. The volunteer labor tends to be very unskilled and unreliable. Dollarwise, the unskilled labor portion of the projects is very small and it is usually quicker and cheaper to employ skilled labor.

Involving the village in decision-making roles and not just as laborers is more important to the success of the project. By being involved in the decisions, the village is, to a large extent, responsible for the success of the system and will be willing to be responsible for the continued maintenance and repair of the systems.

The initiative for undertaking improvements to the village system should come from the village itself. A representative from the Development Planning Office or the Department of Public Works should be available to the village for help in organization, as a liaison in dealing with various A.S.G. agencies and for technical assistance with the system design. If it has not done so, the village should be encouraged to form a Water Committee that would be responsible for coordinating the village decision process, collection of required funds, coordination of the construction process, and ultimate management of the water system operation.

The village should be required to pay a part of the construction costs, not because the funds are necessary to complete the water system, but because the contribution of funds is part of the participation process. The collection of funds for the construction of churches or other village projects is very much a part of the culture and life style of small villages and if encouraged, could be applied to water system improvements.

Water Consumption

One of the first steps in the design of a water system is the determination of water demands. The water demands of a village-type community in a developing area are dependent to a great extent upon the type of waste disposal system to be utilized.

The common industrialized society's solution to waste disposal is through the use of waterborne sewage transport. This involves dilution of the waste with potable water. The resulting sewage, mostly water, is flushed through a system of subterranean pipes and pumping stations to one discharge point. Because direct discharge of large volumes of waste is detrimental to the receiving water, the objective then becomes one of repurifying the water and reconcentrating the waste. The dilution-reconcentration process makes little sense economically or in terms of resource conservation. Flush toilets for water transport of wastes utilize the majority of water consumed in a residential structure.

A.S.G. planning should investigate alternate waste disposal technologies to determine if some other system would be acceptable to the community without the utilization of large quantities of potable water and the high cost of sewerage.

Surface Water

The vast majority of villages currently use surface water streams or springs for their source of water supply. Surface waters are the easiest and cheapest to develop and are the first to be developed. There are several problems that must be addressed when utilizing surface waters.

The quantity of flow varies with each season. The short, steep streams of American Samoa have a very rapid runoff, and as the 1971 and 1974 dry season demonstrated, base flows rapidly diminish after several weeks without rain. The narrow, steep watersheds also make it difficult, if not economically impossible, to construct dams that can contain sufficient water to carry over through a long dry season. A surface water source is only as good as its low flow unless a substantial volume of water is stored for use during the low flows encountered during the dry season.

The high intensity rains of American Samoa wash sediment and debris into the streams that must be removed from the water. Current federal regulations have very high standards for water quality. To meet these standards most surface water sources would, as a minimum, require sedimentation, filtration and disinfection treatment processes. These processes are expensive to build and difficult to maintain. To be bacterially safe, the watersheds above a stream intake should be set aside to nearly a natural state. All access to the watershed should be controlled. This is a very difficult problem in American Samoa where land is scarce and villagers traditionally raise their own crops on the lands above the villages.

Ground Water Wells

Ground water typically offers the best possibility of a high quality water with minimum treatment and storage requirements. The quality and quantity of ground water normally remains relatively constant over time. Barring mechanical problems, once a well is drilled and successfully tested, it can be expected to be a reliable source of water for many years. Chlorination would normally be the only recommended treatment requirement.

The main problem with ground water wells is that they require a pump and motor which require maintenance and operation effort and expenses. Past experience with wells in villages has not been good. The equipment is not maintained and sooner or later breaks down, leaving the village without water. A backup well and pump should always be provided.

The drilling of wells requires an expenditure of funds and is not always successful. Because of this and a lack of understanding of ground water, the community does not generally support wells as a water source. A public education program could do much to relieve many of the misunderstandings. Exploratory well drilling programs along the narrow coastal plain in which the majority of villages are located have indicated that the quantity of ground water is limited. The alluvial fills are highly weathered and have limited quantities of developable water. However, most villages have some potential for ground water that should be investigated. The A.S.G. test well drilling program is scheduled to inventory the ground water of most villages that are currently outside of the A.S.G. water system. This information would aid the villages in master planning their water system objectives.

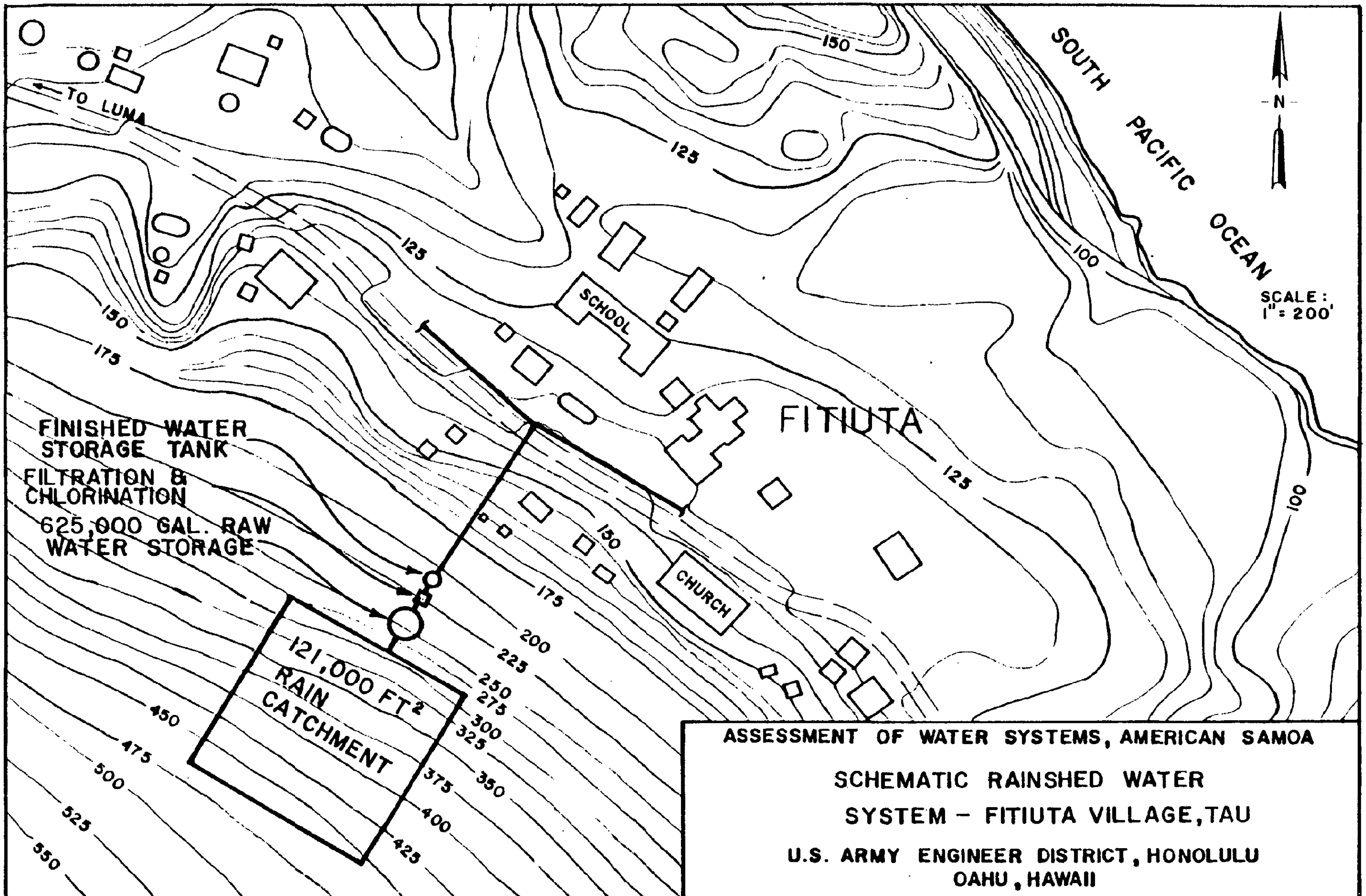
Village Rainshed Catchment Systems

Certain villages which lack both surface and ground water supplies could develop a village-wide rainshed system to provide water. Typically, this system consists of a large impervious area to collect rain and storage facilities to contain rainfall runoff for drier periods. These systems can provide high quality water with simple slow sand filtration and chlorination.

The village-wide rainshed systems require a relatively large capital investment that is far beyond the capabilities of a village and would probably have to be developed and operated with assistance from the A.S.G.

Because of the high development costs, the design of these systems assumes strict control over water usage to prevent waste. The attached schematic designs and preliminary cost estimates for two villages (Aoloaufou and Fitiuta) give some idea of the size and cost of these systems (Figures VI-3, VI-4, VI-5 and VI-6). Aunuu village also has characteristics that would make a rainshed catchment system attractive. The Aunuu system could be designed to mix the high quality rainshed water with the high chloride ground water presently utilized in Aunuu Village.

The primary disadvantages of rainshed systems are their relatively high development costs and the fact that the catchment structure and storage facilities can not be economically constructed large enough to supply water through all rainfall probabilities. An economic decision would be made to size the system to provide design water demands in eight out of ten cases, nine out of ten cases, or some other frequency. Shortages during low rainfall years would be met by alternate sources and/or strict rationing.



ASSESSMENT OF WATER SYSTEMS, AMERICAN SAMOA

SCHEMATIC RAINSHED WATER SYSTEM – FITIUTA VILLAGE, TAU

U.S. ARMY ENGINEER DISTRICT, HONOLULU
OAHU, HAWAII

FIGURE VI-3

ASSESSMENT OF WATER SYSTEMS
AMERICAN SAMOA

FIGURE VI-4

PRELIMINARY DESIGN
FITIUTA VILLAGE WATER SYSTEM

1. **POPULATION**

YEAR	POPULATION
1974	441
2000	502*

*0.5% increase per year

2. **WATER CONSUMPTION**

ASSUMPTIONS:

1. No industrial or commercial use
2. 50 gallons per capita per day consumption
3. Strict controls (meters) over water use
4. Government operated system

   502 people x 50 gallons/day x 365 days = 9,161,500 gallons

5. Mix in 2,500 gallons per day from existing brackish well

2,500 gallons/day x 365 days	=	912,500 gallons
Gallons required from catchment	=	8,249,000 gallons

3. **REQUIRED CATCHMENT AREA**

Assume 110 inches rain/year (90% probability rainfall)

$$\frac{8{,}249{,}000 \text{ gallons/year} \times 12 \text{ inches/foot}}{7.48 \text{ gallons/cu. ft.} \times 110 \text{ inches/year}} = 120{,}306 \text{ square feet}$$

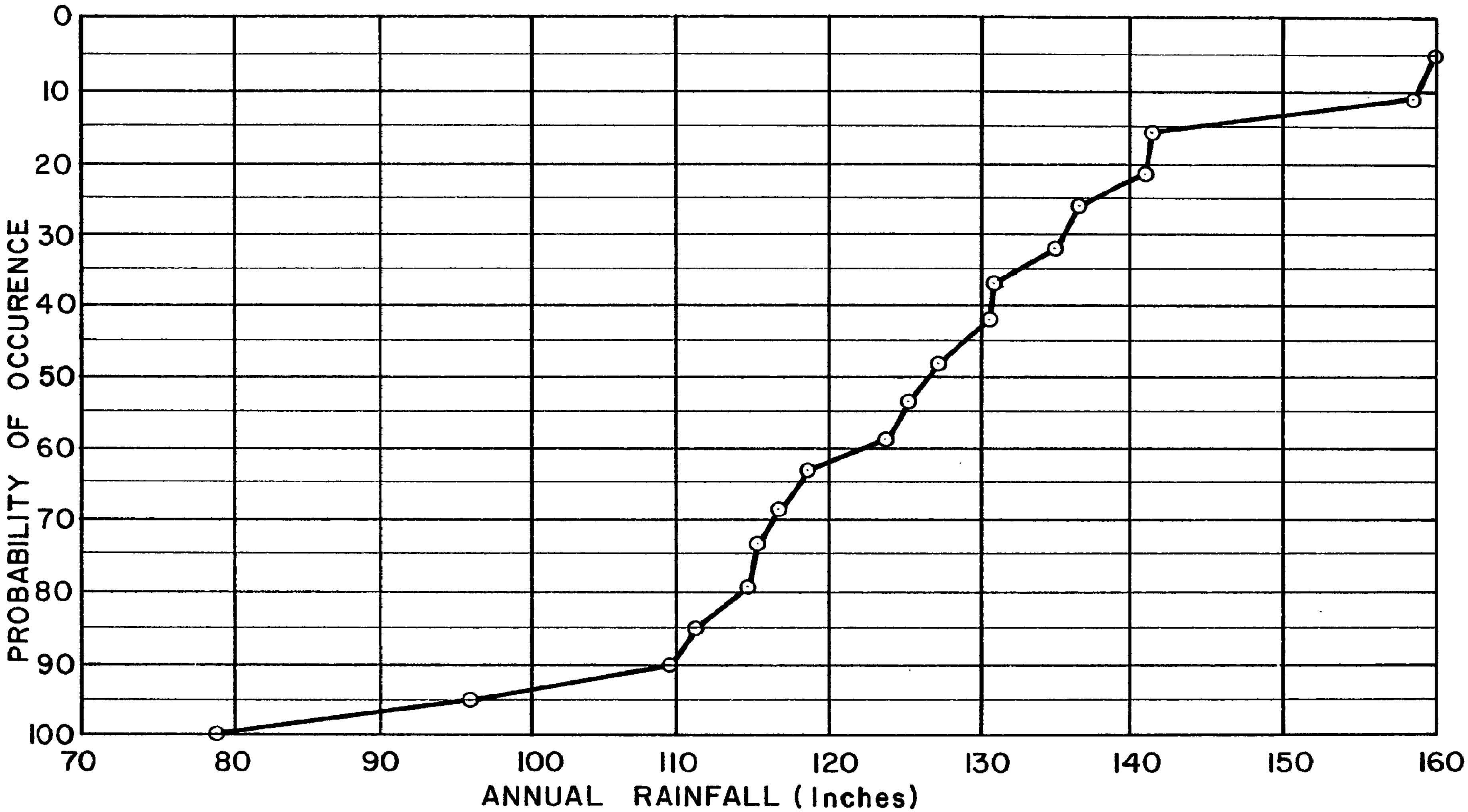
4. **STORAGE SIZING**

(per mass storage calculations)

625,000 gallon storage reservoir required

5. **COST ESTIMATE**

1. Storage tank (625,000 gallon)	=	$175,000
2. Rubber lined catchment (120,306 sq. ft. @ $1.50)	=	180,500
3. Treatment & miscellaneous	=	75,000
Subtotal	=	$430,500
Contingencies 15%	=	65,000
TOTAL	=	$495,500
SAY	=	$500,000

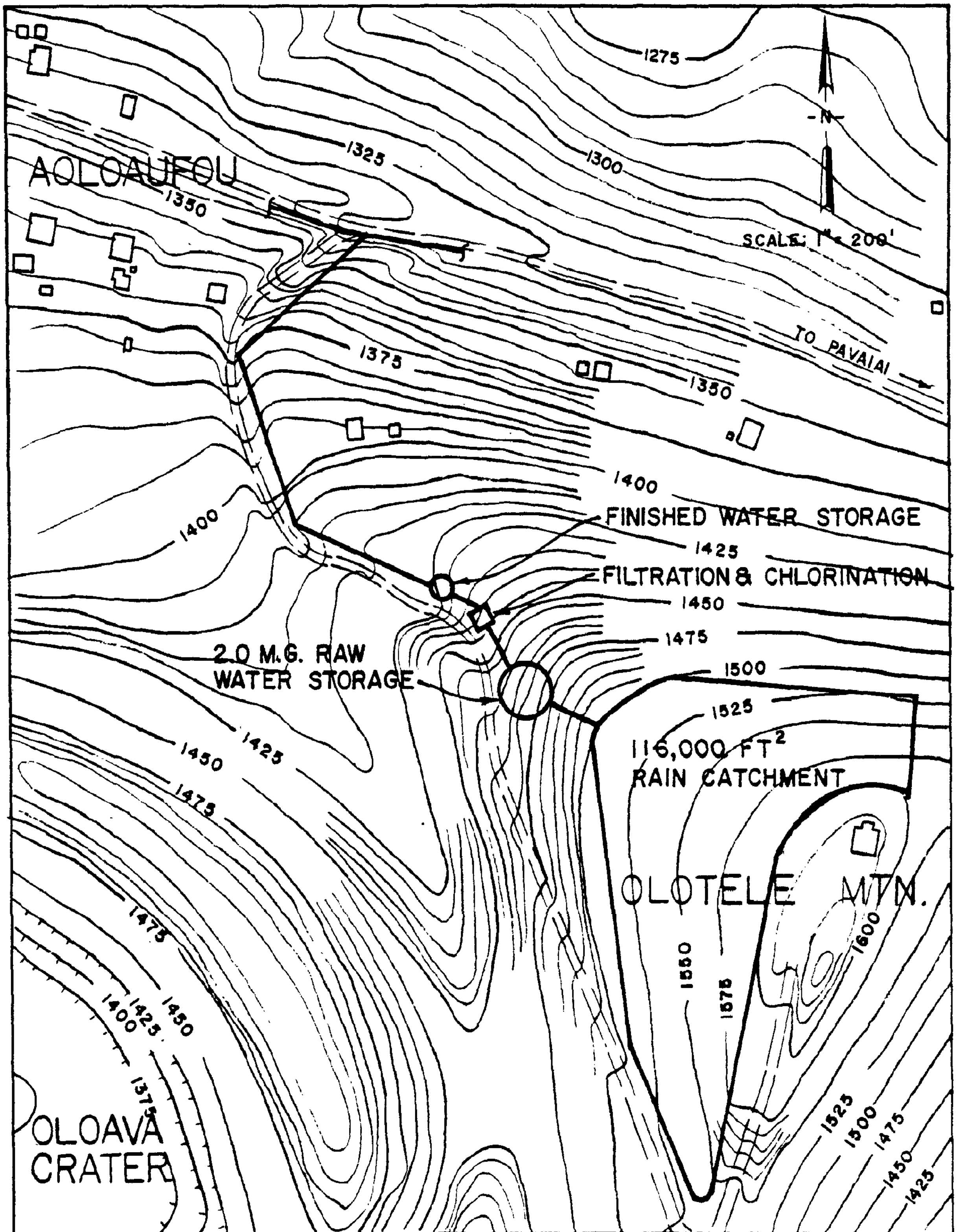


ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

FIGURE VI-5

RAINFALL PROBABILITY AT TAFUNA AIRPORT



ASSESSMENT OF WATER SYSTEMS, AMERICAN SAMOA

SCHEMATIC RAINSHED WATER
SYSTEM - AOLOAUFOU VILLAGE

U.S. ARMY ENGINEER DISTRICT, HONOLULU
OAHU, HAWAII

FIGURE VI-6

ASSESSMENT OF WATER SYSTEMS
AMERICAN SAMOA

FIGURE VI-7

PRELIMINARY DESIGN
AOLOAUFOU VILLAGE WATER SYSTEM

1. **POPULATION**

YEAR	POPULATION
1974	410
2000	1137*

*4% increase per year

2. **WATER CONSUMPTION**

ASSUMPTIONS:

1. No industrial or commercial use
2. Strict controls (meters) over water consumption
3. Government operated system
4. 75 gallons per capita per day consumption
5. Existing spring average flow 40 gpm

1137 people x 75 gallons per day x 365 days	=	31,125,400 gallons
Less 40 gallons/minute x 1440 minutes/day x 365 days	=	21,024,000 gallons
Gallons required from catchment	=	10,101,400 gallons

3. **REQUIRED CATCHMENT AREA**

Assume 140 inches/year rainfall as per Faga'alu rain station (90% rainfall probability)

$$\frac{10{,}101{,}400 \text{ gallons/year} \times 12 \text{ inches/foot}}{7.48 \text{ gallons/cu. ft.} \times 140 \text{ inches/year}} = 115{,}753 \text{ square feet}$$

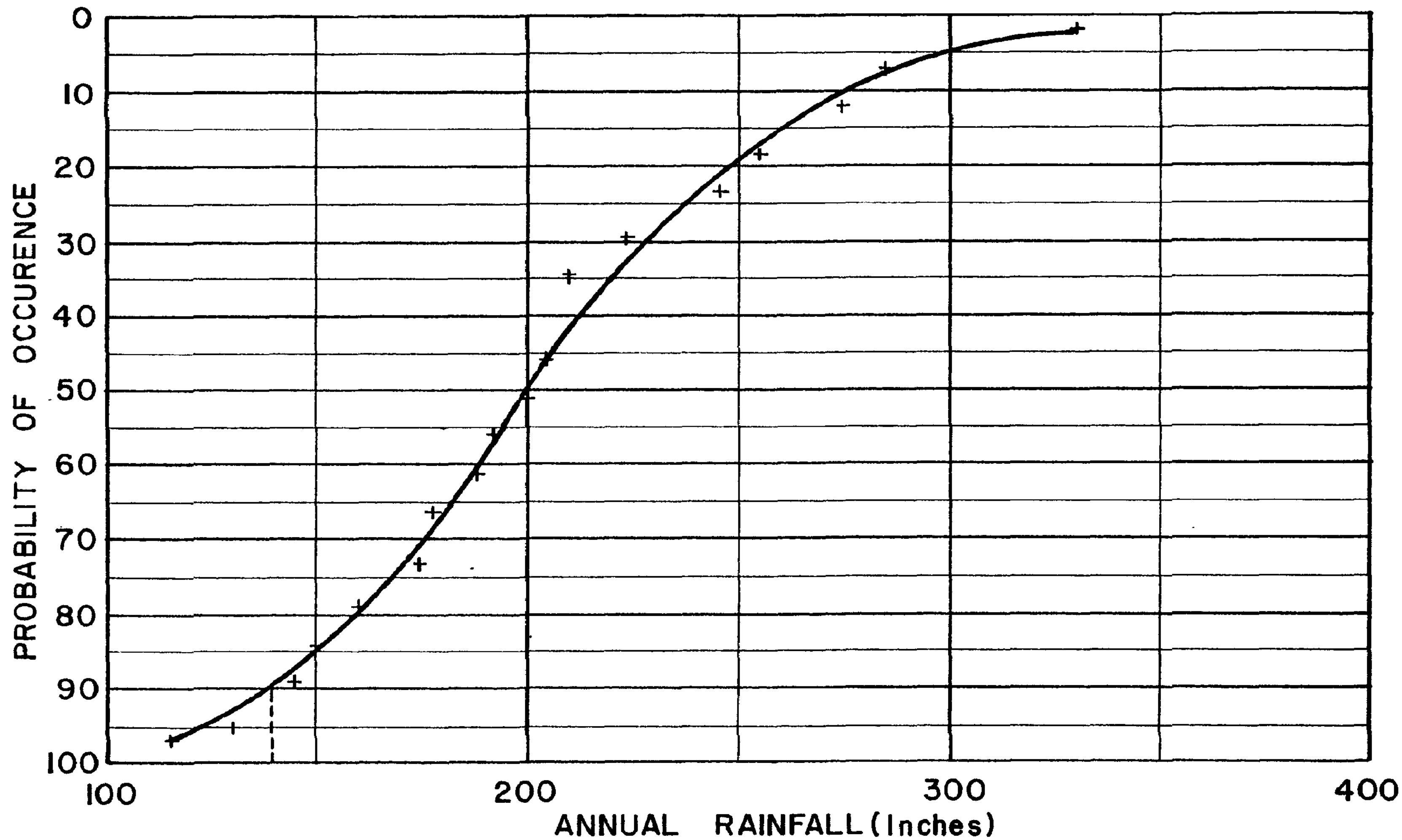
4. **STORAGE SIZING**

(per mass storage calculations)

2.00 million gallon storage reservoir required

5. **CATCHMENT SYSTEM COST ESTIMATE**

1. Storage tank (2.0 M.G.)	=	$550,000
2. Rubber lined catchment (1.50/sq. ft.)	=	174,000
3. Treatment & miscellaneous	=	75,000
Subtotal	=	799,000
Contingencies 15%	=	120,000
TOTAL	=	$919,000
SAY	=	$925,000



ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

FIGURE VI-8

<u>RAINFALL PROBABILITY AT UPPER FAGAALU RESERVOIR</u>

Individual Roof Catchment Systems

Many homes presently utilize runoff from roofs for water supply purposes. Except for a very few, these systems are primitive and runoff is only collected in barrels and buckets from roof downspouts.

A few homes have more advanced systems with adequately sized gutters, storage tanks, and pressurization systems. Some of these systems have proved to be successful in the relatively evenly distributed annual rainfall of American Samoa.

Calculations for a typical system in American Samoa in an area with 100 inches of rainfall per year and an allowance for only 50 gallons of water per person per day indicate that the individual roof catchment system would require 300 square feet of roof area and 1500 gallons of storage capacity per person in the household. Reservoir storage capacity was determined by mass storage calculations which assumes that storage will be depleted coincidentally with the first rains of the wet season.

A consumption rate of 50 gallons per person per day is low by most standards. There have been no studies on the actual consumption rates in American Samoa, and it is possible that through strict control of water usage, the head of a household could reduce water consumption to a lower rate. Perhaps a demonstration project could be developed that would provide more information on water consumption.

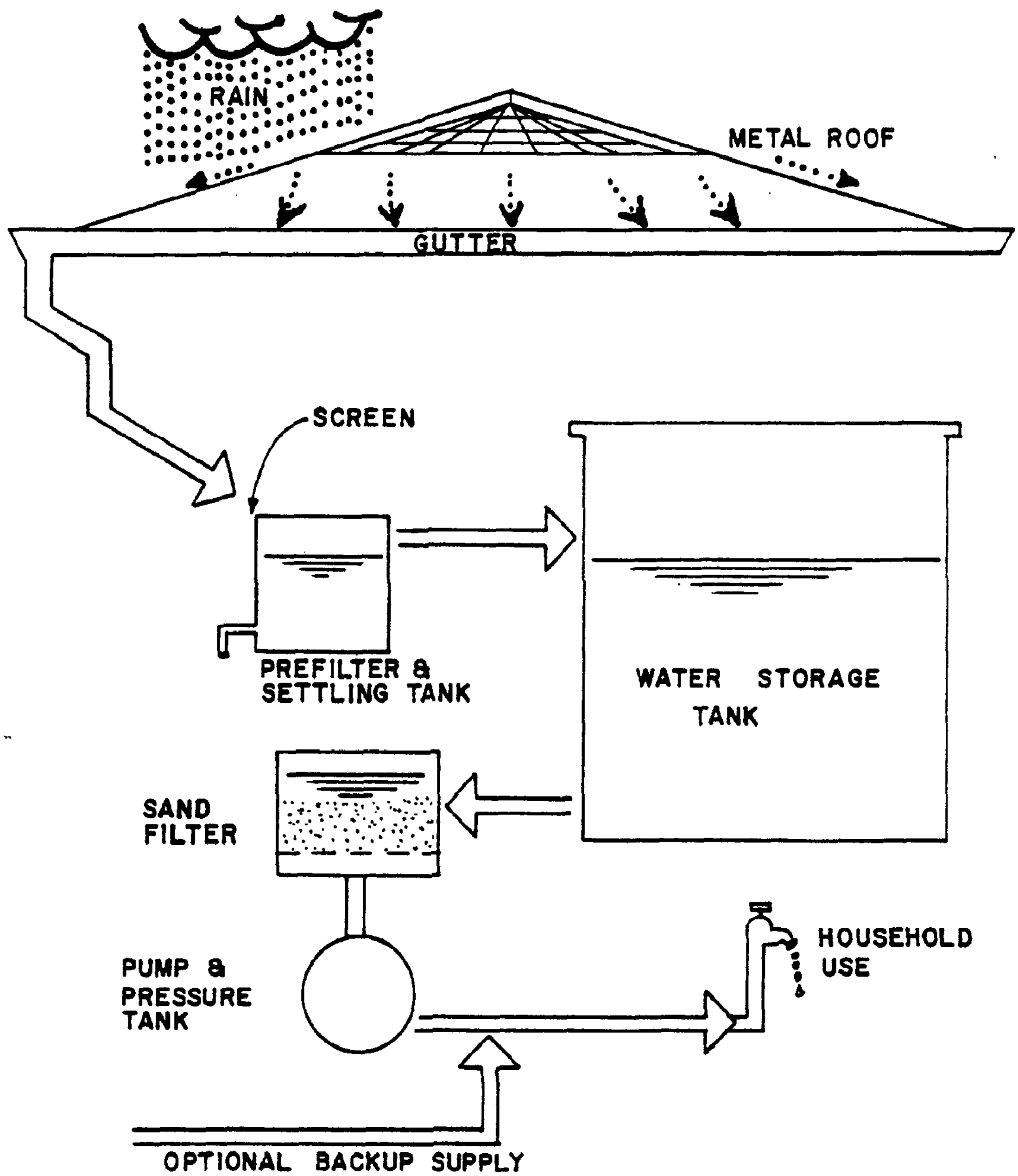
With a consumption rate of 50 gallons per person per day, the typical U.S. household of 3.5 persons would require a storage capacity of some 5,000 gallons and a roof area of slightly over 1000 square feet. Samoan households average 7.4 persons per household (see 1977 annual report) and would require facilities over twice as large. A typical Samoan residence has far less than the required 2200 square feet of roof area and would require special additions for the extra catchment area.

Roof catchment systems can be of several types. To eliminate the need for pumping to pressurize the system, a catchment roof and storage tank can be constructed as a separate structure from the residence. The structure will have to be elevated above the residence by either building an elevated structure or by siting the structure on elevated ground. In this system, the size of the catchment area is usually limited by economics to an area roughly equal to the size of the tank roof. The system, therefore, can not be relied upon for continual supply and requires a backup source. The backup source can be either a village or the A.S.G. system. The backup system, however, may be experiencing the same water shortages during low rainfall periods.

The separate structure system could be constructed in American Samoa using locally available materials (galvanized iron roof catchment and 5000 gallon ferrocement tank) and skills for less than $1,000.

A catchment system that utilizes the roof area of the residence could also be easily constructed (Figure VI-9). The roofs should be of galvanized iron or some other nonorganic material that does not impart a taste or color to the water as do wood shingles or composition roofing. The roofs of existing homes are sometimes difficult to incorporate into a roof catchment system because of the materials used for construction or because their layout makes collection of all runoff difficult. However, new home roofs can easily be planned for efficient collection.

The roof catchment system requires a pump and pressure tank if adequate pressures are to be maintained in the residence. The pump increases the maintenance requirements and reduces reliability. A pumped system would cost approximately $1500 in American Samoa.



ASSESSMENT OF WATER SYSTEMS, AMERICAN SAMOA

ROOF CATCHMENT SYSTEM

U.S. ARMY ENGINEER DISTRICT, HONOLULU
OAHU, HAWAII

FIGURE VI-9

Any roof catchment system will experience shortages at one time or another because it is impossible to construct a system large enough to cover all rainfall probabilities. With proper management of water, though, the shortages can be reduced to a minimum.

RIGHT-OF-WAY ACQUISITION

General

The procurement of right-of-way for construction of improvement programs has historically been the source of problems and delays for the American Samoa Government. The difficulties can be traced directly to administrative problems, a lack of policy guidelines, and the unique Samoan communal land ownership arrangement. The problem also relates to the reluctance of the A.S.G. to take a firm stand on the issue because of a fear that it may be violating the nonalienation of native lands policy. The A.S.G. also feels that a firm stand may not be popular in the small island community. The avoidance of confronting right-of-way issues and the urgent need for water system improvements have sometimes caused projects to be modified at the expense of higher construction costs or operational efficiency.

The difficulty in obtaining right-of-way can also be viewed as a measure of the public's lack of knowledge concerning the A.S.G. water program. This unawareness of A.S.G. improvement programs in turn leads to apathy and nonsupport of the programs. The present policies do not stress public involvement, and this is exemplified by the tradition of making public contact for the first time only when attempting to obtain right-of-way for projects. An individual who is not informed about proposed plans and objectives of the improvement programs will have little confidence in the programs and little sense of community duty to cooperate in providing right-of-way.

Recommended Policy and Procedures

After a review of the problem areas within the Right-of-Way Branch of the Department of Public Works, the following revisions to the present system are recommended:

1. The American Samoa Government should adopt a policy to expedite right-of-way acquisition by instituting condemnation proceedings under the public domain authority vested in the A.S.G. when an agreement is not reached by negotiation with the landowner within a reasonable time.

2. Establish a Right-of-Way Branch in the Department of Public Works staffed by engineers, surveyors, draftsmen, right-of-way men, trained appraisers, lawyers, and other personnel required for efficient and prompt right-of-way acquisitions. Whenever necessary, long-term (five year) contracts of employment could be made with skilled personnel to maintain continuity in the Right-of-Way Branch.

3. Arrange public hearings in cooperation with the Office of Samoan Affairs before a final selection is made of the right-of-way route in the village or villages affected. The public hearings will identify the landowners, problems with the selected route, and problems in obtaining land values and lease rentals in the area by the appraisers.

4. In the negotiation stage, the American Samoa Government should initially make an offer to purchase the property from the landowner. If an agreement is not reached, the A.S.G. should have appraisers investigate the property and make an official appraisal of its market value. The landowner would then be given an official notice that states the property is to be taken, given a description of the property, and sets forth the amount the A.S.G. will pay. If the amount is acceptable to the owner, the purchase of the property will be

secured by an agreement between the A.S.G. and the owner. If the amount is acceptable, but there is a dispute as to the ownership of the land, all parties claiming ownership should execute a release. A writ of interpleader would be filed by depositing the agreed upon amount with the High Court and the Court would determine ownership for the purpose of distribution of the amount deposited with the Court Registry. If an agreement cannot be reached, then condemnation proceedings should be instituted immediately.

5. Abolish the crop damage schedule of payments system and make payments pursuant to the fair market value of the land by the official appraisers. A landowner refusing to accept the official appraisal value may seek to prove by competent evidence that the compensation is inadequate for past, present, and prospective loss to the property not taken as a measure of compensation. The owner may also show the special adaptability or availability of the land for its highest and best use as a measure of increasing the compensation. It should be noted that as long as the taking is for the public use, the only matter remaining would be the award of just compensation to the landowner.

6. The Right-of-Way Branch budget should be set for a longer term (three years) to allow a review of right-of-way acquisitions during that period and estimate the budgetary needs of the Right-of-Way Branch. The Budget would have to be audited on an annual basis to determine whether or not a special appropriation will be necessary to meet the right-of-way acquisitions that exceed the estimated cost for particular projects or for new projects that were not a part of the original budget consideration. Advance payments for monthly or annual rentals for right-of-way acquisitions or leases should be discouraged and be subject to approval by the budget officer for the Right-of-Way Branch.

7. Enact legislation to authorize the Right-of-Way Branch to enter land for the purpose of making preliminary surveys and plans prior to the commencement of proceedings to acquire land for public use. After determination of ownership, record surveys of right-of-way acquisitions that describe ownership and boundary lines in the Office of the Territorial Registrar. This will provide a record of land ownership and boundary definitions whenever the A.S.G. takes land for public use under a right-of-way acquisition.

8. The Office of the Territorial Registrar should adopt indexing systems that will increase the efficiency of retrieving land sale records, leases, easements, condemnation and right-of-way acquisitions. The American Samoa Government should assist the collection of statistics on written lease agreements that are not recorded with the Territorial Registrar or informal oral lease rent agreements by taking a survey of commercial and residential rentals in the Territory of American Samoa and making the information available to the Right-of-Way Branch.

9. Enact legislation to require the mandatory posting of a bond or surety to secure temporary restraining orders seeking to restrain right-of-way acquisitions.

Cultural Considerations

The cultural aspects to be considered in condemnation and right-of-way acquisitions would involve the direct infringement on the Samoan concept of their inalienable rights to the land. The A.S.G., past and present, had zealously supported the policy to protect Samoan lands. Since 1961, the A.S.G. policy has been to encourage negotiations for right-of-way acquisitions and not to use condemnation proceedings. This policy may have contributed to many of the problems described in Chapter V.

The villages of Fagatogo and Pago Pago represent a unique problem that is not completely cultural, but it still presents a major obstacle to any right-of-way acquisition for waterlines and monitoring water use by meters in these villages. The villages rely on an agreement between Commander Benjamin F. Tilley, U.S. Navy, and the Chief of Fagatogo and the Chief of Pago Pago, dated August 23, 1899. In the agreement, the Navy agreed to "two pipe hydrants for the public use in the village of Fagatogo" in exchange for "three hundred dollars and the exclusive right to construct and maintain a reservoir, pipeline, and all necessary connections and fittings". Many residents in these villages have interpreted the agreement to mean that they have a right to free water from the A.S.G. water system ("public hydrant") and are reluctant to surrender this assumed privilege. The 1899 Tilley agreement may be considered a treaty with the United States entered into prior to the Deed of Cession in 1900 which would raise a legal question. To be effective a treaty must be adopted by the President of the United States and approved by two-thirds of the United States Senators present at the time of approval.

The primary cultural objection that would be raised in every right-of-way acquisition is the erosion of the Samoan way of life ("fa'a Samoa"). Every taking of land for public use, directly affects the authority ("pule") of the chief ("matai") over land that he exercises control over for his extended family. The Pago Pago Well Condemnation, Airport Acquisition, and Dairy Farm cases, however, demonstrate that condemnation proceedings can be effectively instituted without seriously affecting the Samoan culture.

WATER SYSTEMS MANAGEMENT

General

Over the short-term, the attention that is now being given to the problems of operation and management of the water system and the coordination with planning functions appears to be a great improvement over past efforts. The development of programs to meet the goals and objectives of the water utility branch are underway and should receive priority attention within WSSW. Outlining these programs and disseminating the information to various departments of the Government of American Samoa would do much to strengthen the understanding of the operational considerations of WSSW in the planning efforts and would define the role of government in water systems development. In addition, weekly staff meetings between the Water Systems Division and Water Utilities would increase coordinatation between the design and operation professionals.

The policy and operational procedures in regards to government intervention in village water systems should be formalized prior to increased government expenditures on the village systems. Because of consistently expressed village sentiment towards maintaining traditional ownership of the water use rights, the DPW goal of owning and operating all water systems and charging customers appears ill-fated. It is recommended that A.S.G. acknowledge village ownership and operation of water systems and only provide services on a work order basis, charging for services rendered. In situations where the Governor determines aid is desirable, he allocates money from a small descretionary fund, called the Small Village Fund. This aid should not be channelled through Water Utility, but through another DPW division. This will reduce public confusion as to the role of Water Utility in operating A.S.G. systems. To accommodate A.S.G. facility requirements, the government should either develop separate water supplies for government facilities served by village systems, or purchase water from the village systems at the same rate for which A.S.G. charges for government supplied water. This approach will not only minimize conflicts, but absolve A.S.G. of many operational responsibilities for village water systems under the Safe Drinking Water Act.

Long-Term Recommendations

Management will receive additional government-wide emphasis through increased budgeting in the fiscal years following FY79. However, a reorganization of the DPW functions dealing with water systems design, construction, maintenance, and operation to take advantage of existing professional talent and to improve coordination, appears desirable. A Water Division could be formed within the Department of Public Works, which would combine planning, design, construction, operation, and maintenance of all water systems under one Assistant Director of DPW. A strong manager with experience in managing multidisciplined organizations would be required. A recommended organization chart for such a Division appears as Figure VI-10. This organization would provide increased engineering expertise for operational decisions without duplicating engineering or support staff efforts in separate design and operation divisions. Additionally, the organization will facilitate increased emphasis on upgrading the distribution system. The additional function of needs assessment was added to form a basis for future planning. Locating all members of the Division in one specific area, and holding weekly staff seminars to discuss plans and operational problems would also increase the coordination of objectives and provide the benefits of additional exchange of technical information. The existing in-service training program should be expanded to include all levels of management, as well as field personnel and the topics expanded to include billing and other management considerations.

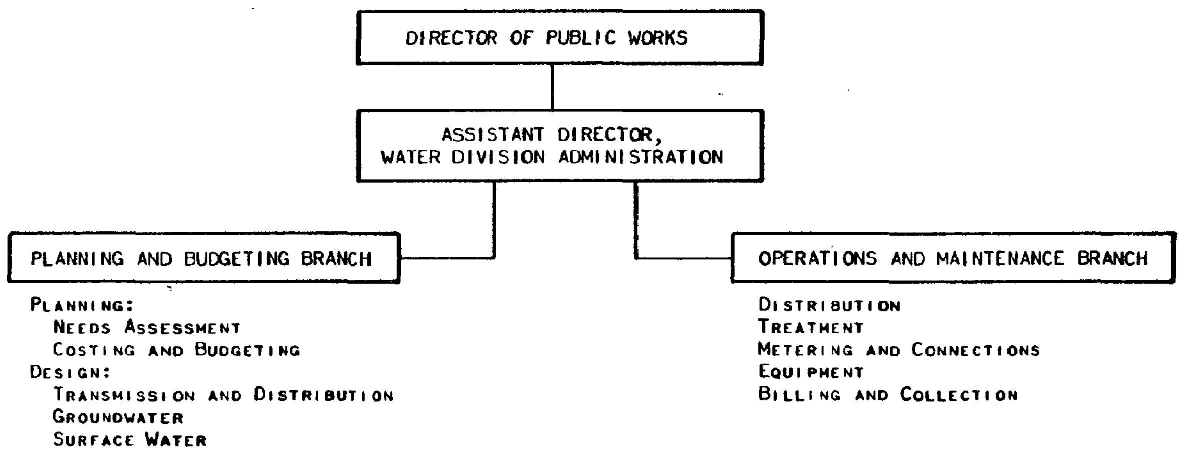
ASSESSMENT OF WATER SYSTEMS

AMERICAN SAMOA

FIGURE VI-10

ORGANIZATION CHART

PROPOSED WATER DIVISION



With the accelerated construction of water improvements in American Samoa, management and operation requirements have increased dramatically over the past 5 years, and will continue. The burden of compensating for past operational neglect and the operation of this new and relatively sophisticated utility system will result in significant demands on management and indicates that bold and forceful changes will be required to correct existing deficiencies and meet the new tasks ahead. Additional repair crews and equipment, meter installation and meter reading crews, mid-level managers, and engineering expertise will be required if the benefits of the new transmission and source development programs are to be extended to the people and if the government is to operate and maintain planned improvements in the best long-term interest of the territory.

Another longer range alternative is the formation of a separate authority such as a Board of Water Supply, and which the formation of a separate Division would be an excellent first step. The Board would presumably have all of the functions of the previously mentioned Division and would operate independently of the Government. This would require development of separate billing, procurement, and other administrative functions. This additional overhead expense does not now appear warranted for the marginal benefits of bypassing political pressure and cumbersome governmental regulations regarding personnel and procurement procedures. A Board of Water Supply concept should be considered as the system size and functions increase.

Long-term planning and policy direction from the highest level of territorial government also needs to be developed. Such items as the philosophy of continual subsidy of the water system or the possibility of system revenue meeting all (or a fixed percentage) of operating costs need to be addressed in the form of governmental policy. The goals of expansion of the system and of increased water quality also require attention. One recommended step, in development of the policy, is to require completion of the Government of American Samoa Operations Manual. This manual, required under the code of American Samoa, is the responsibility of the Lt. Governor. Policy and operational procedures contained in the manual would be a basis for action on the department level.

To reduce public suspicion and distrust of water system management, an ongoing public awareness program should be incorporated into WSSW activities. The program should include both formal and informal public hearings, and weekly television news coverage of system changes. Dissemination of information on how the system operates and the problems encountered by DPW would be of value. Announcing failures and successes in solving difficult problems will also do much to narrow the gap between public expectations and DPW capabilities. This mutual understanding will do much to improve water system management, from which the people of the territory will ultimately benefit.

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APPENDICES

APPENDIX A

GAS SYSTEM WATER USAGE REPORTS

GAS SYSTEM WATER USAGE - OCTOBER 1977 *

Village	Number of Accounts	Flat	Metered Consumption, MG	Estimated Unmetered Consumption, MG	Largest Metered Consumption, MG	Largest Unmetered Consumption, MG	Estimated Residential Population Served	Primary Water Sources	Remarks
Futiga	50	None	.622				300	Iliili well	
Iliili	48	"	.872		John Viena .985		600	Iliili well	
Vaitogi	76	"	1.357				700	Iliili well	
Pava'ia'i	45	"	.486				800	Malaeimi well	Some mixing from Iliili well.
Mapusaga Fou	16	"	.144				100	Lagopuna catchment	School serve primarily by catchment.
Faleniu/Mapusaga	22		1.975		C. College 1.927		250	Malaeimi well	
Malaeimi	25	"	.726		Kong Yung .215		100	Malaeimi well	
Faganeanea/Nu'uuli	169	02	3.711		Coca Cola .731		4200	A (Tafuna Wells	
Tafuna					FAA Housing .204			(Water catchment	
Fatumafuti	07		.130		Kong Yung .315		100	A	
Fagaalu	38		.587				400	B (A (Fagaalu catchment	Inland service on catchment only.
Utulei	87	28	2.867		Rainmaker-2.036 Standard Oil .116 Morris S- .112		900	B Utulei well	High services on well only.
Fagatogo	151	42	2.221		Lumana'i .148 Meadow Gold .240		1800	C (B (Fagatogo catchment	High service on
Pago Pago /Satala	202	48	5.183		B.F.K. 1.007 Solia R. .257		2400	D (C (Utumoa catchment (Pago well	One familu on Fitula catchment. High service on
Atu'u	34	04	.417						
Canneries	02		11.319		SK 7.295		500	Utumoa catchment D	
Leloaloa	18	"	.319		VC 4.024		200	D	
	990	125	32,930 MG	-141.1			13,350		
Total Water Accounted for:	74.0 MG								
Total water output for month of Oct.	134.7 MG				% accounted for: 54.9%				

* Approximately 10% of consumption of metered non-cannery customers.

GAS SYSTEM WATER - November 1977

Village	Number of Accounts	Flat	Metered Consump- tion, MG	Estimated* Unmetered Consump- tion, MG	Largest Metered Consumption, MG	Largest Unmetered Consumption, MG	Estimated Residential Population Served	Primary Water Sources	Remarks
Futiga	50	-0-	.301				300	Iliili well	
Iliili	44	-0-	.668		~~John Viena 90,000~~		600	Iliili well	
Vaitogi	76	-0-	1.231				700	Iliili well	
Pava'ia'i	45	-0-	.390				800	Malaeimi well	Some mixing from Iliili well.
Mapusagafou	17	-0-	.097				100	Lagopuna catchment	School serve primarily by catchment
Faleniu/Mapusaga	24	-0-	2.363		College 1.924		250	Malaeimi well	
Malaeimi	27	-0-	.985		Kong Yung .228		100	Malaeimi well	
Nuu'uli/Tafuna/ Faganeanea	165	02	3.734		Coca Cola 1.428 FAA Housing .296		4200	A (Tafuna wells (Water catchment	
Fatumafuti	07	-0-	.144				100	A	
Fagaalu	35	-0-	.554				400	B (A (Fagaalu catchment	Inland service on catchment only
Utulei	86	28	2.939		Hotel 1.843 Morris S. .288 S. Oil .109		900	B Utulei well	High service on well only.
Fagatogo	143	42	2.117		Lumana'i .194 Meadow Gold .246		1800	C (B (Fagatogo catchment	High service on catchment only
Pago Pago/Satala	202	48	5.069		AAA Gym .132 Korea House .375 Soli's Rest .305 B.F.K. 1.429		2400	D (C (Utumoa catchment (Pago well	One family on Fitula catchment
Atu'u	33	04	1.444		Fishermen C. .818		500	D	
Canneries	02		16.672		SK-8.908			D	
Leloaloa	18	01	.281		VC-7.764		200	D	
TOTALS	974	125	36.969	42.4	26.413		13,350		
Total water accounted for:	81.4			Water unaccounted for: (Leaks, illegal connections)					
Total water output for month of November:	154.2								
% Accounted for:	52.8%								

* Approximately 190% of consumption of metered non-cannery customers.

GAS SYSTEM WATER [illegible] - DECEMBER, 1977

Village	Number of Accounts	Flat	Metered Consumption, MG	Estimated * Unmetered Consumption, MG	Largest Metered Consumption, MG	Largest Unmetered Consumption, MG	Estimated Residential Population Served	Primary Water Sources	Remarks
Futiga	53	None	1.487				300	Iliili well	
Iliili	47	None	.821				600	Iliili well	
Vaitogi	178	None	.843				700	Iliili well	
Pava'ia'i	53	None	1.010				800	Malaeimi Well	Some mixing from Iliili well.
Mapusagafou	20	None	.333				100	Lagopunacatchment	School serve primarily by catchment
Faleniu/Mapusaga	28	None	2.665		College 1.325		250	Malaeimi Well	
Malaeimi	25	None	.691		Kong Yung .166		100	Malaeimi Well	
Nu'uuli/Tafuna) & Faganeanea	175	02	4.777		FAA Housing .339 Coca Cola 1.428 Kong Yung .673		4200	A (Tafuna Wells (Water catchment	
Fatumafuti	07	None	.623				100	A	
Fagaalu	40	None	1.263				400	B (A (Fagaalu catchment	Inland service on catchment only.
Utulei	93	28	2.783		Rainmaker 2.198 Morris Scanlan .113		900	B Utulei well	High service on well only.
Fagatogo	155	42	2.270		Lumana'i .131 Meadow Gold .240		1800	C (B (Fagatogo catchment	High service on catchment only.
Pago pago/Satala	220	48	5.907		BFK 1.429 Soli's Rest .196 AAA Gym .155		2400	D (C (Utumoa catchment (Pago well	One family on Fitula catchment. High service on Utumoa only.
Atu'u	41	04	.903		SK 6.246		500	D	
Canneries	02		13.882		VC 7.606			D	
Leloaloa	20	01	.663				200	D	
TOTALS	1,057	123	40,921	51.4			13,350		
Total Water Accounted for:	92.3MG			Water [illegible] accounted for: ([illegible] connections)					
Total Water out put for month of December	131.8								

* Approximately 190% of consumption of metered non-cannery customers.

GAS SYSTEM WATER [illegible]SE - JANUARY, 1978

Villages	Number of Accounts	Flat	Metered Consumption, MG	Estimated* Unmetered Consumption, MG	Largest Metered Consumption, MG	Largest Unmetered Consumption, MG	Estimated Residential Population Served	Primary Water Sources	Remarks
Futiga	55	None	1.401				300	Iliili well	
Iliili	45	None	.457				600	Iliili well	
Vaitogi	76	None	1.732				700	Iliili well	
Pava'ia'i	45	None	.887				800	Malaeimi well	Some mixing from Iliili well/
Mapusaga Fou	20	None	.519				100	Lagopuna catchment	School served primarily by catchment.
Faleniu/Mapusaga	26	None	1.663		College 1.242		250	Malaeimi well	
Malaeimi	25	None	.936		Kong Yung .259		100	Malaeimi well	
Nu'uuli/Tafuna & Faganeanea	165	02	2.456		Coca Cola 1.400 FAA Housing .267		4200	A (Tafuna wells, (Water catchment	
Fatumafuti	07	None	.108				100	A	
Fagaalu	38	None	.636				400	B(A (Fagaalu catchment	Inland service on catchment only.
Utulei	83	None	3.455		Rainmaker 2.627		900	B Utulei well	High service on well only.
Fagatogo	150	42	2.702		Lumana'i .113 Meadow Gold .190 M. Bird .275		1800	C(B (Fagatogo catchment	High service on catchment only.
Pago Pago/Satala	212	48	4.351		AAA Gym .107 K. House .242 Soli's Rest .202 BFK- .835		2400	D(C (Utumoa catchment	One family on Fitula catchment.
Atu'u	35	04	.582				500	D	
Canneries	02		12.029		SK - 7.254			D	
Leloaloa	18	01	.379		VC - 4.775 (Suspect meter underregistration)		200	D	
TOTALS	1005	125	34.293 MG	42.3			13,350		
Total water accounted for:	76.6 MG				% accounted for 56.6%				
Total water Output for January:	135.4 MG								

* Approximately 90% of consumption of metered non-cannery customers.

APPENDIX B

<u>GROUND WATER DEVELOPMENT</u>

<u>IN AMERICAN SAMOA</u>

GROUND WATER DEVELOPMENT

IN

AMERICAN SAMOA

U.S. ARMY ENGINEER DISTRICT, HONOLULU

AUGUST 1978

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IN

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INTRODUCTION

Purpose and Scope

The purpose of this report is to summarize and evaluate available information and data on ground water development in American Samoa. The report was prepared by the U.S. Army Engineer District, Honolulu, in assistance to the American Samoa Government (ASG).

This presentation will include a summary description of the geology and hydrogeology of the five major inhabited islands of American Samoa, an historical overview of ground water development, a technical evaluation of available information and data, and, finally, conclusions and recommendations.

Geology and Hydrogeology

General. The geology and hydrogeology of the Samoa Islands have been described by Stearns (1944), Davis (1963), Stice and McCoy (1968), and Bentley (1975). The following discussion was extracted from their reports and supplemented by more recently acquired information.

The islands of American Samoa are part of the Samoan Archipelago, which lies roughly 1,000 miles south of the equator and forms a westward-trending chain. The principal islands of American Samoa are Tutuila, Aunu'u, Ofu, Olosega and Ta'u. These form the eastern part of the archipelago and extend over a distance of about 100 miles. Ofu, Olosega and Ta'u are collectively called the Manu'a Islands and are situated about 65 miles east of Tutuila.

All five islands are of volcanic origin and exhibit the rugged topographic relief common to many Pacific islands. Table 1 lists the area and maximum altitude of each of these five islands.

TABLE 1

SURFACE AREA AND MAXIMUM ALTITUDE OF EACH ISLAND

Island	Surface Area (Square Miles)	Max. Altitude (Feet)
Tutuila	53.0	2,140
Aunu'u	0.6	300
Ofu	2.0	1,590
Olosega	1.5	2,090
Ta'u	15	3,050

In his report Ground-Water Reconnaissance of American Samoa, Davis (1963) presents the following discussion (based on Stearns, 1944) of those geological features of the five islands that are pertinent to the occurrence of water.

> "Tutuila is made up chiefly of basaltic rock that was erupted from five volcanoes arranged in a rough east-west line. The major activity, which occurred at four centers in Pliocene or early Pleistocene time, produced shield-shaped masses that merged into a single elongate island, longer and broader than the present Tutuila. After activity at the four centers ceased, deep valleys were cut by streams, and the shoreline retreated under the attack of waves. Toward the end of Pleistocene time, the island had been reduced to approximately its present size and form. More recently, the fifth volcano became active and built the Tafuna-Leone plain, and a small submarine eruption off the east end of Tutuila built the tuff cone that is now Aunuu. During the subsequent erosional period, sedimentary deposits were formed at the foot of steep slopes, on valley floors, and along the coast. The general character of the rocks on the island and their relative ages are shown in the following stratigraphic section (Table 2).

TABLE 2

Stratigraphic section of Tutuila (after Stearns, 1944) and water-bearing characteristics of the rocks

Geologic age	Formation	Thickness (feet)	General character	Water-bearing characteristics
Recent	Sedimentary rocks	200+	Alluvium on valley floors; talus at foot of steep slopes; calcareous sand and coralline gravel along coast.	Alluvium in mouths of valleys is moderately permeable and contains fresh to brackish water. Talus locally yields water in seeps and small springs. Sand and gravel contain small supplies of fresh water.
	Leone Volcanics	200+	Olivine basalt in pahoehoe-lava flows; tuff in cones and veneer over lava flows; ash and cinder in cones.	Lava flows under Tafuna-Leone plain have moderate to high permeability and may contain considerable fresh water at about sea level. Tuff and ash have low permeability and yield little water. A few small springs flow from cinder.
	Aunuu Tuff	200+	Tuff forming Aunuu island.	Low permeability and yields little water.
			Erosional unconformity	
Pliocene and earliest Pleistocene (?)	Trachyte	2,140+	Trachytic dikes, plugs, and crater fill younger than most of the Pliocene volcanics.	Low permeability. Yields water in high-level seeps and small springs.
	Taputapu Volcanics	1,639+	Thin-bedded olivine basalt with interbedded tuff beds and cinder cones.	Moderate permeability. Yields water at many scattered high-level seeps and small springs.
	Pago Volcanic Series (extra-caldera volcanics)	1,609+	Lower member of thin-bedded olivine basalt; includes thin dikes and thin tuff beds. Upper member of massive basaltic and andesite flows; interbedded tuff and cinder deposits.	Moderate to low permeability. Yields water at many scattered high-level seeps and small springs.
	Pago Volcanic Series (intra-caldera volcanics)	2,141+	Massive basaltic and andesitic lava flows and some interbedded tuff and breccia and cinder cones; few thin lenses of gravel.	Mostly low permeability. Yields water at scattered high-level seeps and small springs.
	Alofau Volcanics	963+	Thin-bedded olivine basalt with numerous dikes.	Lava flows between dikes have moderate to high permeability. Rocks yield water at many high-level seeps and small springs.
	Olomoana Volcanics	1,074+	Olivine basalt and andesitic basalt; interbedded cinder cones and tuff beds.	Moderate permeability. Yield water at many high-level seeps and small springs.
			Erosional (?) unconformity	
	Masefau dike complex	200+	Thin basaltic flows cut by many dikes.	Low permeability. Yield little water.

Source: Davis, 1963

"The large number of eruptive centers in a small area, the overlapping of rocks erupted from different volcanoes, and the presence of dikes and interbedded tuff, cinder, and breccia among the lava flows have produced complex geologic conditions on Tutuila. The bulk of Tutuila is formed by aa and pahoehoe lava flows that range from thin-bedded flows with high permeability to thick-bedded dense flows with low permeability. The late flow rock on the Tafuna-Leone plain is mostly thin bedded, but on older parts of the island, particularly along the coast, the flows are mostly thick and dense.

"Dikes are dense and impermeable, and where their spacing is close, they may reduce greatly the permeability of the rock that they cut. Unweathered tuff may have moderate permeability, but weathered tuff is almost impermeable. The breccia is mostly dense and has low permeability. The permeability of fresh cinder is high, but it may be greatly decreased by weathering because of consolidation that occurs during chemical decomposition. Lava flows, although they far exceed the other types of rock in total volume, are divided by dikes and interbedded tuff and breccia into units which are irregular in size and shape. The total vertical and horizontal extent of any unit of flows is small as compared to the size of the island.

"The sedimentary rocks of recent age consist of talus, alluvium, calcareous sand, and coralline gravel. The talus is poorly sorted material, in which large blocks are prominent, accumulated at the bottoms of steep slopes along the coast and in steep-walled valleys; the permeability of the talus is variable. Thick deposits of alluvium, comprising poorly sorted mixtures of clay, sand, gravel, and boulders derived from volcanic rock fill extends below sea level at the mouths of some valleys and has a permeability ranging from low to high. The calcareous sand and gravel are composed of material originating in the reefs that fringe a considerable part of the island and are most abundant in beaches at the mouths of valleys; the calcareous deposits generally are more permeable than the alluvium.

"Beneath a part of the late volcanic rock underlying the Tafuna-Leone plain are sediments that were deposited before the eruption of the Leone volcanics. The nature and extent of these deposits are not known, but they probably consist partly of talus and mainly of calcareous beach deposits and alluvium.

"Tutuila's satellite island, Aunuu, is an indurated bedded tuff produced by submarine volcanic explosions. The tuff, in general, is relatively fine grained and has been altered sufficiently by weathering to make the material nearly impermeable. The coastal flat on the west and northwest sides of the island is underlain by material washed down from the cone and by permeable deposits of calcareous sand and gravel."

The Manu'a islands--Ta'u, Ofu and Olosega--were built by volcanic activity along the crest of the easternmost portion of the Samoan Ridge (Stice and McCoy, 1968).

The largest volcanic center in the Manu'a islands was at Ta'u where basaltic flows of Pliocene and Pleistocene age built a single shield rising more than 12,000 feet above the ocean floor and more than 3,000 feet above sea level. After the collapse of the summit of the shield, the partial filling of the caldera to a depth of more than 1,000 feet and a long interval of erosion, a complex of tuff deposits of Holocene age extended over the northwest corner of the island near Faleasao; and, at about the same time, flows of basalt and olivine basalt built the shelf at Fitiuta at the northeast corner. The island consists mainly of thin-bedded lava flows. Dikes are few and widely scattered except on the south side of the island where a swarm of dikes and sills are exposed. Beach deposits of sand and gravel lie along most of the shore and a fringing reef borders much of the island (Davis, 1963; Bentley, 1975).

Ofu and Olosega were built by basaltic flows of Pliocene age from two shields that coalesced to form one island. Partial collapse of both shields and erosion by streams and the sea has cut deeply into the original island and has reduced it to two small steep islands separated by a narrow channel. Both of these islands, like Ta'u are composed of thin-bedded basaltic lava flows whose permeability is high. Numerous dikes cut the lava flows on the east end of Ofu and the west end of

Olosega. Sedimentary deposits of talus is common at the foot of the cliffs, in stream valleys and around the coast. Deposits of calcareous sand, gravel and cobbles mantle considerable parts of the shore of each island. Coral reefs surround most of both islands (Davis, 1963; Bentley, 1975).

Occurrence of Ground Water. According to Bentley (1975), rainfall is the source of all fresh groundwater in the islands. Rainfall that infiltrates into the ground and is not retained in the soil zone or lost through evaporation or transpiration by plants, percolates downward, and eventually recharges subsurface aquifers.

High-level (or perched) ground water and basal ground water are the two principal types of aquifers found in the islands. High-level ground water is impounded or perched above sea level and separated from seawater by dikes and other geologic barriers. In some cases, the permeable zones between widely spaced dikes are highly productive aquifers. However, where the space between dikes is small, the compartments are likewise small and the overall storage is smaller because of the larger proportion of dike rock to permeable rock (Davis, 1963). In the latter case, these compartments are low yield aquifers. Numerous springs that maintain the base flow of perennial streams, especially on Tutuila, are supplied by high-level aquifers where water is discharged over low points of dikes.

Basal ground water is the water found near sea level in aquifers that are hydraulically connected with the ocean. It includes the seawater in the rocks and the fresh to brackish to saline lenses which are maintained by freshwater recharge and float on the heavier seawater, or saltwater. The water in these lenses generally moves seaward when recharged sufficiently and discharges in narrow zones along the coastline. It should further be noted that because of the direct hydraulic connection with the ocean, the basal ground water lense is also influenced by ocean tides. Tidal fluctuations are particularly evident where the basal lens is thinnest (usually near the coastline) and, therefore, an important consideration in selecting ground water development areas.

The basal ground water lens is also called the Ghyben-Herzberg lens after the co-discoverers of the principle that describes the phenomenon of freshwater floating on heavier saltwater. In sum, the Ghyben-Herzberg principle states that about 40 feet of freshwater below sea level is formed for each foot of freshwater above sea level to maintain hydrostatic equilibrium. Upon application of this principle, it also implies that if a cone of depression is formed about a well in freshwater, saltwater may rise 40 feet for each foot of drawdown (Linsley et al, 1958).

None of the ground water found thus far in the islands is under appreciable artesian pressure. All of the ground water discussed in this report is, therefore, believed to be under unconfined, free aquifer, non-artesian, basal watertable conditions.

<u>Tafuna-Leone Plain</u>. According to Davis (1963) and Bentley (1975), the most promising area for development of ground water on the main island of Tutuila is the Tafuna-Leone Plain.

This semi-circular shaped coastal plain extends from Nuu'uli to Leone and measures three miles north to south by five miles east to west. Its surface area is about 10,000 acres. It is bordered on the north and west by a sharp crested spiny ridge which rises 1,000 to 2,000 feet in elevation above the plain. To the south, or ocean side, the plain is marked by a coral limestone fringing reef, 800 to 1,500 feet wide. The reef surface is at or near low tide level. The surface of the plain rises to the north from 10 feet along the ocean to 200 feet and more above sea level at the toe of the spiny crested mountains, a rise of one foot in 50 feet or about one degree slope. The Tafuna-Leone coastal plain is the only flatland on Tutuila except for a few small alluvial valley floors.

The lava flows which formed the Tafuna Plain came from a north-south trending rift zone on the west side of the plain extending through Olotele to Olovalu to Futiga to Fogamaa cones and craters. The age of the flows is probably Holocene and may be only a few thousand years old judging by the youthful appearance of the cones, the freshness of the rock, and absence of a developed soil profile. The lava flows left surface mounds and ridges consisting of rough assemblages of red cinders (volcanic slag) and scoriaceous masses. On steeper slopes the flows are bordered by agglutinated splashes and veneers of glassy, vesicular rock. The porous structure of the rock is caused by the development of gas bubbles from the supersaturated lava and water vapor resulting from internal stirring of the lava which leaves voids or vesicles. There is no pattern for the vesicles found in the upper part of the individual flow layer but in the middle and lower parts, the bubbles or voids, which were occupied by gas, become elongated into tube-like forms as the stiff, viscous material in which the bubbles are entrapped continues to move. The average alignment of vesicles is often parallel to the direction of flow. There are other elements in the fabric of volcanic rocks beside vesicle alignment that show preferred orientation and can be correlated with flow direction of partly congealing lava. These elements are: sub-parallel alignment of feldspar laths; parallel orientation of alternate bands of crystalline and glassy basalt; and microjoints, slightly wavey, pencil-thin lines, or bands that are formed by tiny connected holes. Brown iron oxide staining has occurred around most of the holes which serves to outline and help identify vesicle (and indirectly lava flow) alignment. Permeability rates through rock layers varies with jointing systems, crack patterns and developed flow channels. Hard, solid lava basalt is considered impervious and not good potential aquifer material.

Borings made for water wells near Tafunafou (one mile north of the airport) revealed thin layers of Pahoehoe olivine basalt alternating with reddish gray clinkers and scoria, a sponge-like rock also known as volcanic slag. Loose pockets, or layers of sand-gravel sized basalt rubble were found in Well 60 (old Well No. T6; see Figure 1). These are considered to be water-worn, rounded pieces of ancient beach and stream deposit formed during lower stands of the sea. The extent and orientation of the old beach and stream deposits are not known.

The basal ground water underlying the plain was found to be only two to three feet above mean sea level in the Tafunafou well field. Unfortunately, the data needed to accurately determine the height of the fresh ground water level relative to mean sea level were insufficient at the time of this writing. Accurately referenced elevation data are essential to determining the thickness of the basal ground water lens in accordance to the Ghyben-Herzberg Principle. Freshwater springs which release basal ground water to the ocean are commonly found along the coastline of the plain at the basalt-coral interface.

Observations made in May 1975 demonstrated certain important characteristics of this coastal plain basal aquifer and, in general, supported previous findings by Davis (1963) and Bentley (1975). Following 4.6 inches of rainfall in 24 hours, the ground water level at the Tafunafou well field rose more than 4 feet (temporary rise of 7 to 8 feet). Subsequently, the basal water level was observed to drop at a rate of 1 foot in 48 hours (unpublished data, U.S. Army Corps of Engineers). These observations indicate that the subsurface geology of at least portions of the Tafuna-Leone plain are highly permeable and have little storage capacity and low hydraulic head. Judging from the rapid rise of the water table after heavy rains and the subsequent rapid decline, the normal static water level probably stands only about one to two feet above mean sea level over a good part of the year in the Tafunafou area.

Based on these previous observations, the basal freshwater lens at Tafunafou can generally be described as a thin, sensitive lens that can be subject to saltwater intrusion problems.

The soil-rock alluvium in the small and steep valleys and narrow coastal plains of the islands are the products of residual decay and weathering. The slow chemical disintegration of extrusive igneous rocks forms sesquioxide clay minerals which act as binding agents, much like iron rust, to unite and cement the soil and rock particles together. Several test holes have been drilled in the narrow and steep valleys around Pago Pago Harbor with unfavorable results. Where water has been found, the quantities are small and the quality is generally objectionable due to some form of pollution.

Historical Overview

Background. The first known effort to develop basal ground water was by the U.S. Navy in 1943 when they built the Maui well system near the head of Pago Pago Harbor. The well system has 325 feet of horizontal infiltration tunnels at the bottom of a shaft 76 feet deep. At the time of construction, the static water level was 24 feet above sea level, and the yield was about 200 gallons per minute (gpm). The rocks cut by the tunnels were lava flows, breccia, and dikes. Two faults were crossed by the tunnels. The high water level and the complex geology exposed in the tunnels indicate that the ground water at the site of the well is impounded (i.e., perched) and separated from seawater by dikes and other geologic structures (Davis, 1963).

Actual well drilling to develop ground water sources started in the 1960's. Although modern well drilling equipment was not available in American Samoa during this period, about 20 wells (in some cases, no more than holes) were drilled with an old percussion drill which was brought from Australia by Darcy J. Gilbert Drilling Company.

Unfortunately, technical guidance was lacking and no records were kept. As a result, information about the drilling work and the efficiency of the completed wells is non-existent. Some of these wells are listed in Table A-1 of Bentley (1975).

In 1962, the U.S. Geological Survey (USGS), in cooperation with the American Samoa Government, expanded its investigation of surface water resources (which had commenced in 1957) to include ground water resources. A description of the availability and chemical quality of ground water based on the USGS data collected over the period 1962-1975 can be found in Bentley (1975).

During the years of 1972 to 1975, ten more wells were drilled by the Hawaiian company, Water Resources International. A Failing Model 1500 rotary drill with clay drilling muds was used. The use of drilling muds for developing water wells in the Tafunafou area, however, was found to be undesirable.

While drilling muds in various forms are often used in oil wells to help bring bit cuttings to the surface and to stabilize the walls of the hole, in water well drilling, the drilling mud escapes into the cracks and openings in water bearing layers (aquifers) and reduces permeability. To achieve the full water yield potential of the aquifer, the mud must be removed. Removal of the mud is costly and time-consuming; and, for these reasons, few contractors will take the time to remove the objectionable clay residue. To avoid these problems, most companies now employ non-contaminating drilling fluids (including self-destructing enzyme-based fluids), the use of a drilling casing, or choose drilling methods that do not require artificial means to remove cuttings.

Unfortunately, the holes drilled during the early 1970's were not properly cleaned, surged and developed and may have contributed to uncorrelatable well pumping results, such as unexplainable salinity variations from hole to hole.

In 1974, American Samoa experienced the most severe drought in recent history. Water had to be trucked to many outlying villages where private water supplies had dried up; and strict water rationing of limited quantitites available from the surface water supplied government system forced the territory's major private industry, the tuna canneries, to shut down operations for about 6 months.

Several federal agencies responded to this critical situation. The Federal Disaster Assistance Administration provided emergency funding to temporarily relieve the situation (Burnham, 1974). The U.S. Geological Survey initiated an investigation to describe and evaluate the availability and chemical quality of ground water in the islands, with emphasis on the Tafuna-Leone Plain on Tutuila (Bentley, 1975) and the U.S. Army Corps of Engineers, Pacific Ocean Division, provided the technical assistance needed for exploratory well drilling and production well construction.

The drought situation and its serious impacts focussed attention on the poor condition of the existing water systems. As a result, the American Samoa Government (ASG) was able to acquire federal grant funds for water systems improvements.

During the period immediately following the 1974 drought, a water systems improvement program was formulated by the local Department of Public Works. As part of this program and in search of more reliable and safe sources of water for the centralized government system, the decision was made to pursue a program that would eventually phase out surface water sources and depend completely on ground water as a source of water for the central system. Economics heavily influenced this decision. A surface water supply study (CH2M Hill, 1975), which was completed not long after the drought, estimated the project cost for an ample supply of water for the island during any dry spell to be $19.5

million. Ground water development, on the other hand, was estimated to require only one-seventh of this amount and would provide a much larger storage capacity (Flanagan, 1976).

In 1976, there were four water producing wells in the Tafunafou well field, averaging between 700 and 1,200 gallons per minute total (combined) yield with chloride contents ranging from 65 ppm to 1,200 ppm. The Iliili area had two wells producing about 200 gpm in 1974.

In the year May 1975 to May 1976, the Ground Water Development Corporation (GWDC, a Samoan drilling company) constructed 15 new water wells using improved methods with screens, sanitary seals, surging, developing and pump testing.

The choice of drilling equipment and drilling and sampling methods (coring preferred) are most important in the discontinuous volcanic rock layers. The down-the-hole percussion drill is limited by loss of air in the voids and cracks in the rock which requires cementing (sealing) the porous layers and slows the drilling rate. Straight rotary drilling is limited by requiring some kind of drilling fluid to seal the walls of the hole and to bring bit cuttings to the surface. Above the ground water level, the method of drilling is not important as long as a straight vertical hole can be made and a sanitary cement seal is placed around the casing. Below the water table, continuous representative samples should be taken in all well construction work. It is also important that the logging, gradation, classification and analysis of the samples be done by an experienced hydrogeologist to establish and maintain the reliability and the quality of the drilling data gathered.

Present Situation. Figure 1 shows the existing water production wells in the Tafuna-Leone Plain area. It is supplemented by Table 3 which is a descriptive listing of the major Tafuna-Leone wells as of June 1978.

It should be noted that the wells shown in Figure 1 serve two separate systems. The wells to the east of Futiga serve the central ASG system and those to the west of Futiga serve the Leone system. Although a plan to combine the two systems has been proposed, it has yet to be implemented.

The current combined yield of the ASG wells was recently reported to be 1,650 gpm, or 2.4 MGD (unpublished data, ASG Dept. of Public Works, May 1978). The Leone wells produce a total of about 0.4 MGD.

As noted in Table 3, several of the proposed production well sites have real estate or right-of-way acquisition problems. Over the years, attempts to successfully develop ground water in American Samoa have been constantly hampered by the local Government's inability to gain access to favorable sites for exploratory drilling and, subsequently, the right-of-way needed to construct production wells at sites determined to have good potential. In some cases, these problems have gone unresolved for years. As a consequence, the primary criteria practiced in the selection of exploitable well sites include not only geological and hydrological characteristics, but also the government's ability to gain access to the site. It is also not surprising, therefore, to find that, in some cases, past ground water development activities have been directed to areas that may not appear to have the most promising potential from a technical standpoint.

A number of attempts to develop ground water sources outside the Tafuna-Leone area have also been made. In general, however, most of the resulting production wells have been relatively low-yielding (i.e., less than 50 gpm). Drilling logs and well records, as well as the results of pumping tests, for selected wells can be found in the appendices of Bentley (1975). The following discussion will briefly describe some of these wells that are still in use.

TABLE 3

LISTING OF MAJOR WELLS IN TAFUNA-LEONE AREA

(August 1978)

Well No. (Old Well No.)	Year of Constr.	Location	Well Depth (Ft Below Ground)	Averaged Performance Data 1/ Pump Rate (GPM)	Chlorides (Cl, mg/l)	Remarks
33 (1A)	1970	Tafunafou	93	194	65	Operational
46 (1)	1972	Tafunafou	92	120	42	Operational
52 (T2)	1973	Tafunafou	100	186	313	Operational
53 (T3)	1973	Tafunafou	150	112	305	Operational
55 (T10)	1974	Tafunafou	180	173	544	Operational
60 (T6)	1975	Tafunafou	125	322	300	Operational
61 (T8)	1975	Tafunafou	125	327	263	Operational
62 (I5)	1975	Iliili	225	207	96	Operational
63 (I6)	1975	Iliili	205	-	-	Abandoned
65 (T11)	1975	Tafunafou	99	200	-	Operational
66 (T16)	1976	Tafunafou	105	330	226	Operational
67	1976	Malaeimi	115	250	-	Operational
68	1976	Tafunafou	104	-	-	DD Problem 2/
69	1976	Malaeimi	175	120	297	Operational
70	1976	Malaeloa	145	150		Operational
71	1976	Tafunafou	106	-	-	RE Problem 3/
72	1976	Tafunafou	160	400	-	Under Const.
73	1977	Malaeloa	137	150	-	No Pump
74	1977	Iliili	240	-	-	RE Problems
75	1977	Malaeloa	190	-	-	Under Const.
76	1977	Iliili	204	200	75	Operational
77	1978	Tafunafou	149	-	-	DD Problem
78	1978	Tafunafou	145	-	-	Abandoned

1/ Computed from available USGS data for period 7 January 1977 thru 6 June 1978.

2/ Serious drawdown problems currently being encountered.

3/ Real Estate or Right-of-way acquisition problems.

NOTES:

1. Current static water level and drawdown data unavailable.
2. All wells are 8-inch nominal diameter cased and screened.
3. Well 55 pumped as demand requires.
4. The well numbering system is based on well 60 (T6), the first well designed and constructed under supervision of POD. The number 60 was arbitrarily assigned to well T6 on the basis that 59 holes have been previously drilled elsewhere on Tutuila.
5. Missing entries due to unavailable data.

SOURCES:

- Department of Public Works, American Samoa Government
- U.S. Army Corps of Engineers, Pacific Ocean Division
- U.S. Geological Survey

The Pago shaft which was built by the Navy in 1943 is still in operation and serves the central ASG system. Its present yield is about 120 gpm. Other attempts to develop wells along the Vaipito Stream in Pago Pago have either been abandoned for sanitary reasons or have resulted in very low-yielding wells.

The village of Tula at the eastern end of Tutuila uses a drilled well as part of its water supply. This 110-foot deep well was built in 1972 and presently yields less than 30 gpm.

The village of Aunu'u on Tutuila's eastern satellite island is served by three shallow dug wells that skim the shallow freshwater lens of the island. One well has been pumping very brackish water for some time now and is expected to be relegated to emergency service upon completion of a current project which is attempting to improve the efficiency of the two remaining wells and to renovate the pumping facilities. To date, this project has accomplished connecting the two wells with 170 feet of slotted pipe laid below sea level (high tide). As a result, both wells have been yielding about 60 gpm (total) of water with satisfactory chloride levels for several months. More collector lines are anticipated to be installed as necessary.

Several villages in the Manu'a Islands rely on ground water. The village of Ofu on the island of Ofu is presently utilizing a 30-foot deep dug well which yields about 30 gpm of good quality water. The pump used at this well, however, suffers from no maintenance.

The village of Olosega on the island of Olosega is also served by a dug well about 36 feet in depth yielding about 30 gpm. According to the villagers, the quality of the water pumped varies from fair to sometimes salty.

On the island of Ta'u, the Manu'a District High School and the villages of Luma, Ta'u, Suifaga and Fusi are served by a drilled well which yields about 120 gpm. This well is, at times, not adequate for all service areas. The village of Fiti'uta uses a small well (less than 10 gpm) near Faga Spring as one of its sources of water. The water pumped from this well is reported to taste salty during rough seas.

RESULTS AND DISCUSSION

Sources of Information and Data

The major sources of information and data used in this report were three governmental agencies: the Department of Public Works of the American Samoa Government, the U.S. Geological Survey, and the U.S. Army Corps of Engineers, Pacific Ocean Division.

The ASG Department of Public Works is, of course, the primary source of information regarding water systems in the Territory and related improvement programs. The Public Works Director and his staff have been very generous in providing the assistance needed in preparing this report.

The USGS through its previous investigations (Davis, 1963, and Bentley, 1975) and its ongoing surface water and ground water monitoring activities is a major source of hydrologic data for the Territory, as well as other Pacific areas.

Since the 1974 drought, the U.S. Army Corps of Engineers has provided technical assistance, as needed, for ground water development to American Samoa. During Fiscal Year 1977, the Corps assisted ASG in initiating an exploratory well drilling program by supplying test drilling equipment along with the technical expertise needed to implement the program. At the end of FY 1977, all drilling equipment was transferred to ASG for the continuation of the exploratory amd well construction program. The knowledge and records gained through this affiliation comprise another valuable source of information and data on ground water development in American Samoa.

Data Evaluation and Analysis

The information and data gathered from the above sources were evaluated and analyzed in an attempt to better define problems and to gain further insight into the ground water situation in American Samoa. The following discussion will focus upon the topics of ground water quantity, ground water quality, and ground water contamination. The data analyzed were, for the most part, extracted from weekly USGS records collected for wells in the Tafuna-Leone area over the period January 1977 to June 1978.

Ground Water Quantity. The only attempt to quantify the amount of ground water in storage in American Samoa was made by Bentley (1975) for the Tafuna-Leone aquifer. Due to the lack of essential data, he was unable to compute an accurate estimate; however, based on estimates of the area, the thickness of the lens, and an assumed specific yield of the aquifer of 0.1, he estimated that the amount of freshwater in storage was probably about 50,000 acre-ft. Average annual recharge to the aquifer which he based on rainfall-runoff characteristics and estimated transmissivity values was roughly estimated at 30,000 acre-ft (about 27 MGD).

Depite the time that has lapsed since Bentley completed his investigation in 1975, an attempt to better estimate available ground water quantities--to include estimates of safe yield or permissible ground water withdrawal rates--cannot be properly performed at this time. Upon examination of available well records and discussions with knowledgeable people, certain discrepancies have been found to exist that limit the type of analyses that can be made. Foremost of these discrepancies was the finding that elevation data were not accurately referenced to mean sea level. The lack of reliable elevation data precludes accurately estimating the thickness of the freshwater lens, ground water storage and changes in storage. At the time of this writing, this problem is being, or has been, rectified by the ASG Department of Public Works.

The pumpage rates for each well is also not known since not all production wells are metered. This problem undermines any attempt to evaluate the performance of each production well and its effects upon the aquifer.

Observation or monitoring wells (as were those drilled by the Corps) are drilled to measure changes that will take place at the bottom of the freshwater lens with either extraction by pumping or recharge from rainfall. The rapidity of change is indirectly a measure of the lens capacity and ultimate potential. In general, rapid response indicates limited storage and slow response suggests larger volumes. Critical changes in the composition of the freshwater lens occur near the bottom and can be used as a signal or warning for overpumping. Knowing the rate of change taking place in the lens per volume of freshwater extracted or recharged allows for a fairly reliable estimate of the size, areal extent and thickness of the lens.

Water wells can be designed, pumps installed and operated, and safe aquifer conditions maintained if all factors influencing change and well efficiency are known. It should also be noted that pumps should be installed at proper depths as a failsafe for overpumping under any circumstances.

Ground Water Quality. The natural quality of fresh groundwater in American Samoa as indicated by available USGS and ASG data is generally very good. Except in areas where saltwater intrusion is a problem, it is suitable for domestic and current industrial uses in the Territory.

The rates of infiltration and percolation of water through the overburden (surface layers) are so rapid that there is little time for much chemical activity (leaching and dissolving). Consequently, ground water is low in total dissolved solids. Because the rocks are relatively new, soil cover is thin and weathering is shallow, the oxides and salts found in older, more decomposed rocks are low to absent in Samoan deposits. As is the case in the Hawaiian islands, the freshwater lens typically contains less than 200 mg/l of total dissolved solids (predominantly chlorides and carbonates).

The National Interim Primary Drinking Water Regulations (effective 24 June 1977) as provided for by the Safe Drinking Water Act of 1974 and its 1977 amendments is applicable to American Samoa. It is administered by the U.S. Environmental Protection Agency. An excellent discussion of the Act and its implementation in American Samoa is presented in The Effect of the Safe Drinking Water Act on American Samoa (Malae, 1975). In addition to describing the island's physical and cultural setting and its water supply situation, Malae discusses monitoring requirements, evaluates the technical capability available on-island for compliance with the Act and analyzes the various costs needed for implementation. Table 4 is taken from Malae (1976) and lists the maximum contaminant levels of the National Interim Primary Drinking Water Regulations and the required monitoring frequencies for both surface and ground water resources in American Samoa.

As is evident from the information presented thus far saltwater, or seawater, intrusion into basal supplies is the most serious and frequently encountered ground water quality problem in American Samoa. It is the predominant factor determining the location and available quantities of developable basal ground water. Over the years, it has also led to the abandonment of many wells.

Although there are several ways to measure saltwater intrusion, the chloride content or concentration, is perhaps the most common method practiced. Chlorides in reasonable concentrations are not harmful to humans. At concentrations above 250 mg/l (as chlorides), however, they

TABLE 4

MAXIMUM CONTAMINANT LEVELS FOR DRINKING WATER*

Contaminant	Maximum Contaminant Level	Monitoring Requirements Surface	Groundwater
Inorganics			
Arsenic	0.05 mg/l		
Barium	1.00		
Dacmium	0.01		
Chromium	0.05		
Lead	0.05	Every three years	Yearly
Mercury	0.002		
Selenium	0.01		
Silver	0.05		
Fluoride			
70.7-79.2 F	1.6		
79.3-90.5	1.4		
Nitrate	10		
Organics			
Endrin	0.0002 mg/l		
Lindane	0.0044		
Methoxychlor	0.1	Every three years	Set by EQC
Toxaphene	0.0005		
2,4-D	0.1		
2,4,5-TP	0.01		
Microbiological			
Coliforms			
Membrane Filter	1/100 ml	Monthly except GAS,	Set by EQC, but
MPN	10% for 10 ml	10 Leone, 4	villages, 1/quarter
	60% for 100 ml		
		Chlorine residuals may substitute 75% of coliform samples; sample daily at least 4 times required coliform samples.	
Turbidity	1 TU monthly avg		
	5 TU at EQC option	Daily	None
Radioactivity Gross alpha			
Gross alpha	15 p Ci/l	None or EQC option	
Combined RA-226	5		
Ra-228			
Others		None	

*National Interim Primary Drinking Water Regulations (effective 24 June 1977).

SOURCE: Malae, A. U. 1976. The Effect of the Safe Drinking Water Act on American Samoa. M.S. Thesis, University of Pittsburgh.

give a salty taste to water which is objectionable to many people. For this reason, the U.S. Public Health Service (in 1962) recommended the limit of 250 mg/l for drinking water and other public uses, although water containing higher concentrations can still be used if better water is not available.

As was found by Davis (1963) and Bentley (1975), the largest amount of developable fresh ground water--hence, the best chance of managing saltwater intrusion--is the Tafuna-Leone aquifer where ground water development has been focused over recent years.

Despite the data limitations discussed previously, the weekly USGS well records do permit a qualitative evaluation of the performances of certain production wells in terms of chloride concentrations. Figure 2 is a compilation of plots for monitored wells in the Tafunafou well field over the period January 1977 to June 1978, with rainfall data (from the weather stationat the Pago Pago International Airport collected over the same period) shown at the top of the figure. It should be noted that data were not available for all Tafunafou wells and, thus, this figure is not representative of all wells individually. The composite data, however, were collected from the combined well field discharge line.

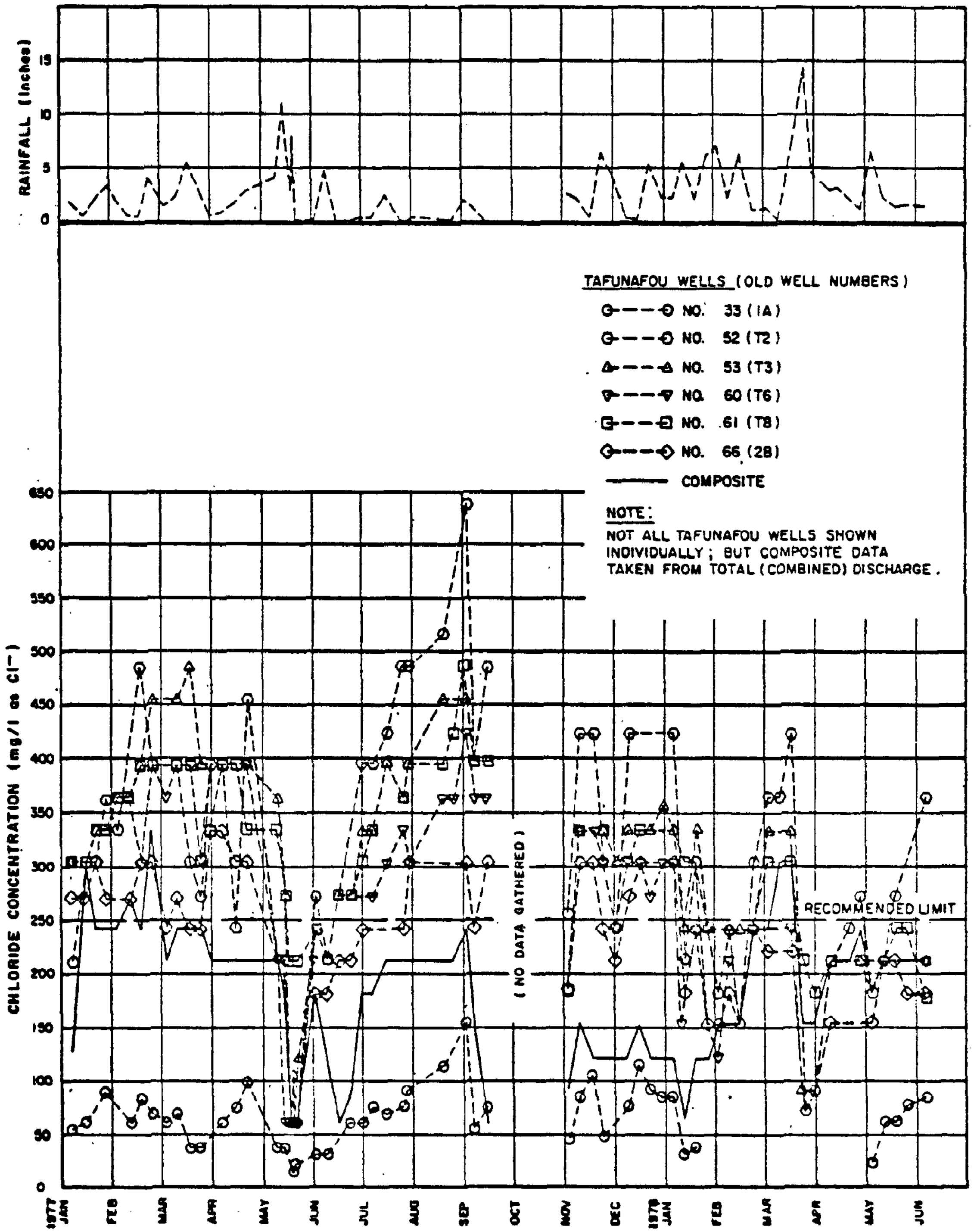
The value of Figure 2 is simply its illustration of the sensitivity of basal lens to rainfall in the Tafunafou area. The almost immediate (about a week or so) appearance of the chloride plots as "mirror-images" of the rainfall plot--particularly after heavy rainfall--is indicative of the sensitive, thin lens that exists in this area and supports previous observations made in May 1975 (see page B-9).

While the composite plot does show that the Tafunafou well field as a whole is still producing good potable water in terms of chlorides concentration, the information gained from Figure 2 appears to highlight

FIGURE 2

CHLORIDE CONCENTRATIONS IN TAFUNAFOU WELL FIELD DISCHARGES

JANUARY 1977 TO JUNE 1978



the limited amount of developable fresh ground water in this portion of the basal lens and cautions against future overdevelopment at this well field.

For comparison, Figure 3 shows available corresponding chloride concentrations for a production well in Iliili (No. 62) and another near the mouth of Malaeimi Valley (No. 69). Neither of these plots illustrates the sharp response to rainfall that has been observed at Tafunafou. In the case of the Iliili well, it may be because of its remoteness to ground water recharge areas. The Malaeimi well also does not appear to be as responsive to rainfall as those at Tafunafou, but has relatively high chlorides concentrations that are not explainable at this time.

Ground Water Contamination. The importance of protecting potable ground water supplies from all sources of contamination cannot be overemphasized. Once contaminated, the integrity of ground water supplies is difficult to restore. Treatment, as is the case with surface water, is expensive; and the economic advantage of having good natural quality ground water is lost.

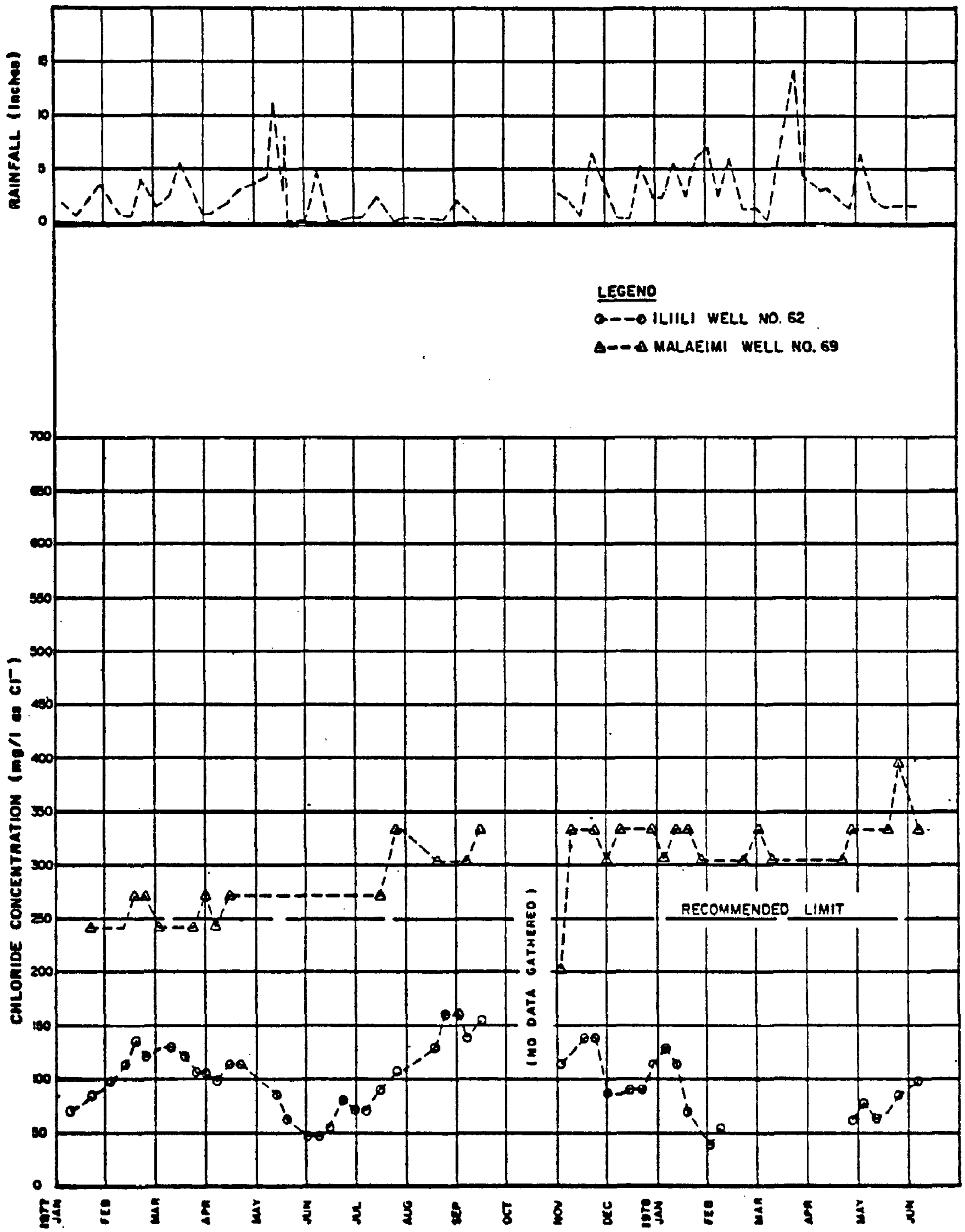
In this regard, watershed management in tributary areas is as important to protecting ground water sources as it is for surface water supplies. Certain practices such as the subsurface disposal of domestic sewage (e.g., via cesspools), other types of wastewaters or the use of toxic substances (e.g., pesticides and herbicides) are likely to be prohibited or stringently controlled.

As a general guideline, one of the first considerations that should be given in ground water development is to select favorable production well sites that are above, or upstream, of anticipated sources of contamination. Ground water under unconfined or water table conditions, like surface water, flows by gravity. Achieving this advantage reduces the need to impose strict land use controls.

FIGURE 3

CHLORIDE CONCENTRATIONS FOR ILIILI AND MALAEIMI WELLS

JANUARY 1977 TO JUNE 1978



Since drilling penetrates the overburden above ground water sources, all drilled holes must also be viewed as potential pipelines for introducing contaminants into subsurface supplies, and precautionary measures must be taken. All observation and production wells should have properly installed sanitary seals. Permanently abandoned holes and wells should be fully grouted and sealed.

Exploratory Well Drilling.

The current exploratory drilling program in American Samoa was initiated by the U.S. Army Corps of Engineers, Pacific Ocean Division (Corps) in assistance to ASG during the summer of 1976. It started with the arrival of a drilling rig complete with tools and supporting equipment and technical Corps personnel from Korea to supervise and perform the test well drilling operation, to train ASG personnel, and to furnish technical direction for well construction by a private drilling contractor (U.S. Army Engineer Division, Pacific Ocean, 1975 and 1976).

Over the following year more than one hundred exploratory and investigation holes and six monitoring wells were drilled by the Corps-ASG drilling team. Technical supervision was also provided in the construction of 13 production wells built during this period.

With one or two exceptions, all holes drilled for observation and monitoring purposes were 8 inches in diameter. All holes were grout-sealed around the casing (in most cases, P.V.C.) and capped to make a complete test well structure. A concrete pedestal was poured around each cased hole at the ground surface and the hole number was permanently printed in the cap. (NOTE: The threaded caps are wrench-tight and are not considered vandal proof. For security reasons, more permanent cap locks may be needed. Further, if any of these observation holes are abandoned, it will be necessary to permanently seal the hole.)

In October 1977, although the Corps personnel returned to Korea, the drilling rig was transferred to ASG for continuation of the exploratory drilling program. Following a period during which ASG lacked the technical expertise needed to continue the exploratory work, the program was resumed in May 1978 upon contracting the services of an experienced hydrogeologist and a well driller.

In view of the information presented in the previous section regarding the threat of saltwater intrusion, it appears that the emphasis of the exploratory program should be focused on locating supplemental ground water sources to alleviate the demand presently being exerted on the basal lens in the Tafunafou area.

The wide and deep Malaeimi and Malaeloa valleys appear to have favorable subsurface conditions for freshwater. Depths to the water table in these valleys are greater than in the Tafunafou area (i.e., 150 feet or more as compared to only 60 to 100 feet in Tafunafou), but the chances of finding more reliable sources of better quality water appear promising. They are both relatively large drainage basins; they are situated landward of the Tafuna-Leone Plain, thus, farther from the coastline and generally above the more populated areas; and, they may be substantial sources of recharge for the Tafuna-Leone aquifer.

Judging from the drilling logs of wells 67, 69, 70 and 73 (see Figure 1), the erosion and shaping of the valleys were accompanied by the deposition of coarse grain sediments (potential aquifer materials) from fluvial and marine sources. Investigations to find, map and test these potential aquifers were among the objectives in Corps plans.

The planned investigations were to drill enough test holes across the mouths of both valleys to be able to correlate boring logs from hole to hole and to prepare geological and hydrological profiles of the basal water conditions. In order to be able to correlate boring logs, the stratigraphic boring log at one particular location has to be interpreted and compared with adjacent borings. The location (spacing) of each individual succeeding boring is made on the basis of the interpretation of the previous boring. The resulting profiles are used to accurately measure the freshwater table level above mean sea level and to observe the response across the valley to tidal action. If conditions are favorable, this information will facilitate the location and construction of larger (12-inch minimum at pump setting) diameter wells.

Production Well Construction.

The construction of efficient and permanent water wells involves two separate and distinct operations: the mechanical aspects of drilling a hole in the ground, and technical supervision, which includes the engineering and design of the well to fit the particular hydrology and geology of subsurface conditions at each individual well site. In the past 20 years, some 60 holes had been drilled on Tutuila without the benefit of technical supervision; as a consequence little is known about their construction other than the location, depth and, in some cases, quality of water. The quality and quantity of water from these holes, especially in the Tafuna-Leone plain, are directly related to the uncontrolled manner in which they were constructed.

Recommended references for water well construction are: Manual No. 7, "Water Well Construction," U.S. Army Engineer Division, Mediterranean; "Ground Water and Wells," published by Eduard E. Johnson, Inc. UOP, Inc., P. O. Box 3118, St. Paul, Minnesota 55165; and "Manual of Water Well Construction Practices," EPA-570/9-75-001, Environmental Protection Agency, Office of Water Supply.

Based on the knowledge and experience gained in American Samoa, the following are some suggested guidelines for the design and construction of production wells:

A. Wells should be sized to yield the safe, maximum quantity and provide two casing sizes of clearance between pump bowls and casing to allow for movement, seismic shifting, construction deviations in alignment or plumbness, and for future maintenance. A twelve-inch diameter is the smallest casing size desirable for wells which produce 250 gallons per minute and more.

B. Well construction techniques practiced by GWDC (Ground Water Development Corporation) were approved by the Corps of Engineers for shallow (less than 200 feet deep) wells and, in general, are suitable in extrusive volcanic aquifers. Modifications and changes in the techniques should not be attempted without the approval of a qualified technical supervisor.

C. Continuous sampling, logging and testing (gradation and classification) should be done below the ground water table level.

D. All permanent water wells should have sanitary seals installed under technical supervision.

E. Elevation of ground water, amount of change and time lag compared with tidal cycle and quality of water with depth will determine the depth of the hole and permanent pump setting.

F. Design of Wells: Length, diameter and slot size of screen (wire wound, continuous slot, welded), position in hole, final depth of hole, yield-drawdown pumping tests and quality of water are important features and should be controlled and recorded.

CONCLUSIONS AND RECOMMENDATIONS

The natural quality of fresh ground water in American Samoa is very good. It meets the maximum contaminant levels set forth in the National Primary Drinking Water Regulations for the parameters measured and is suitable for domestic consumption and current industrial uses in American Samoa. The problems encountered over the years are primarily due to the previous lack of technical expertise and other management and training needs.

The following is a summary of the problems identified in this study and the short-term and long-term recommendations developed in solution to these problems.

Problems Identified.

A. Saltwater Intrusion. Due to the "sensitivity" of the thin basal freshwater lens near the coastline, saltwater, or seawater, intrusion has been a constant threat to ground water development in certain areas, such as the Tafunafou well field.

B. Ground Water Contamination. The potential for ground water contamination due to indiscriminate waste disposal practices and improper watershed management is another constant threat to the integrity of ground water supplies. This problem is enhanced by the existence of abandoned, unsealed holes and wells which can serve as direct pipelines to ground water supplies, as well as production and observation wells with inadequate sanitary seals.

C. Right-of-Way Problem. Attempts to successfully develop ground water in American Samoa have been constantly hampered by the government's inability to gain access to favorable sites for exploratory drilling and, subsequently, the right-of-way needed to construct production wells at those sites determined to have good potential.

D. Lack of Technical Expertise. In the past, the lack of qualified technical expertise (viz., experienced hydrogeologists and well drillers) to supervise and direct both the exploratory drilling and production well construction programs has resulted in well construction records of little or no usefulness and poorly constructed wells.

E. Inadequate Operating Data for Production Wells. Inadequate operating data precludes evaluating the performance of each production well and exercising proper well field management. Each production well should be metered and should be equipped for static water level and water quality monitoring.

F. Insufficient Observation Well Data. Except for a few sites, observation wells are generally not monitored regularly.

G. Inaccurate Elevation Data. At the time of this writing, elevation data needed to determine the thickness of the basal freshwater lens with reference to mean sea level were found to be inaccurate and prohibited a quantitative analysis of the Tafuna-Leone aquifer in this study. This problem is being, or has been, rectified by the ASG Department of Public Works.

Short-Term Recommendations

A. Exploratory Well Drilling Program:

1. Avoid over-development of the basal freshwater lens in the Tafunafou area by directing ground water development programs to other areas.

2. Investigate the potential of the Malaeimi and Malaeloa valleys which appear to be the most promising areas at the present time, as supplemental sources of ground water for the central government system.

3. Conduct a ground reconnaissance survey of villages outside the existing government system with water supply problems to identify and inventory those which are eligible for further ground water exploration. The importance of having a qualified hydrogeologist to provide the technical expertise needed for this survey cannot be overemphasized.

B. Ground Water Contamination:

1. Institute a program to seal abandoned and unsealed drilled holes and wells and to assure that production and observation wells in use have adequate sanitary seals.

2. Select production well sites above, or upstream, of anticipated sources of contaminants, insofar as possible, to minimize the need for strict watershed management and conflicting land uses.

3. Coordinate waste collection and disposal (wastewater and solid waste) and land use practices and plans to assure protection of ground water supplies.

C. Production Well Construction:

1. Maintain the qualified technical expertise required in the engineering, design, and construction of wells to fit the particular hydrology and geology of subsurface conditions at each individual well site and to oversee the mechanical aspects of well drilling (see section on Production Well Construction in text for suggested guidelines).

Long-Term Recommendation

A. Develop a Hydrologic Budget for the Island of Tutuila. A hydrologic, or water, budget is a method of quantifying the four phases of the hydrologic cycle (i.e., precipitation, evaporation and transpiration, surface water and ground water) and their interactions for a given area. It is particularly useful in managing water supplies and in evaluating and forecasting the impacts of certain actions (e.g., dry spells, projected growth and demand, etc.) on each hydrologic component. It requires extensive data collected through well-conceived monitoring programs over extended periods.

For American Samoa, the hydrologic budget should encompass the whole island of Tutuila as a complete hydrologic unit with special focus on the Tafuna-Leone aquifer because of its importance as the primary source of ground water. The U.S. Geological Survey and the National Weather Service are the primary agencies responsible for gathering hydrologic and meteorologic data in American Samoa. Discussions with USGS have revealed that their data gathering programs are directed toward this objective. ASG should continue to coordinate their monitoring efforts to complement those of USGS and the National Weather Service for the purpose of someday acquiring this capability.

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APPENDIX C

REVIEW OF EXISTING LITERATURE

REVIEW OF EXISTING LITERATURE

A review of existing literature serves to provide a setting for this report. It gives an idea of the problems and concerns that faced the Department of Public Works during the development of the water system and gives insight as to why certain courses of action were pursued.

The review will provide a bibliography which is as complete as possible for future studies or engineering designs for the water system. It will also help to identify areas in which data is lacking and more study or data collection is required.

The literature review will be presented in nearly a chronological order so that it will show a somewhat logical development of data as the water system itself developed and expanded.

Literature Review:

1. Report Covering A Master Planned Water Supply and Distribution System for the Pago Pago and Tafuna Areas, Austin, Smith & Associates, Inc., February 1963.

This report noted the growing population and industrial growth in the Pago Pago Harbor and Tafuna areas and pointed out the inability of surface water sources to meet water demands. The report recommended the construction of nearly seven million gallons of distribution and raw water storage. It also recommended interconnecting the three Bay Area water systems and providing slow sand filters and chlorination to the surface water sources.

In an attempt to eliminate the complete dependence on stream flow, the report recommended construction of two shallow wells and a more detailed evaluation of the ground water potential of the Tafuna Plain.

The authors noted a high per capita water consumption and estimated that 40% of the water used was unnecessary or wasted.

2. Water Supply and Distribution Systems Pago Pago and Tafuna Areas, Austin, Smith & Associates, Inc. April 1966.

This report is an operations manual for the water system as improved by construction under the recommendations of the 1963 report. In addition to system operation instructions, the report pointed out the necessity of developing basal ground water supplies to insure a safe and adequate water supply during low rainfall periods.

3. Inventory of Village Water Systems in American Samoa, R.H. Dale, U.S. Geological Survey, November 1970.

This report tabulates the estimated water demand, the presently developed supply, and the estimated availability of water for all villages on Tutuila, American Samoa. The report is based upon limited data obtained during a brief visit to each village during October of 1970. Of necessity, much of the data is estimated and the results are reported in a generalized manner.

4. Report Covering Salt Water Fire Protection System, Roger L. Sinclair, May 1971.

This study investigated the existing Bay Area water system for its fire protection capabilities. The report listed the following conclusions and recommendations:

1. Existing storage capacity of 5.25 million gallons in the Bay Area is adequate if reservoirs are kept at least 30% full.
2. The existing surface water sources are unreliable.
3. The existing distribution system has been poorly operated and as a result, large volumes of water are wasted and reservoirs can not be kept full.

4. The present schedule for improvements to the water system will not provide adequate fire protection for at least three years.
5. The solution for immediate relief of the fire protection problem is to utilize the vast quantity of salt water in Pago Pago Bay.
6. By designing the salt water system in accordance with the water system master plan, the pipelines can be converted to the fresh water system when the fresh water system becomes more reliable.

5. Report Updating the 1963 Master Planned Water Supply and Distribution System including the Leone Plan; Austin, Smith & Associates, Inc., April 1972.

This report documented the tremendous population growth rate in the Pago Pago Bay area and Tafuna Plain area from 1960 to 1970. Population in these regions was growing at an annual average rate of 5.7%.

Water consumption had also increased because of the increasing population and increased industrial activities. The 1990 demand in their study area (which extended from Leone Village to Breakers Point) was estimated at 7.8 million gallons per day.

The report noted that large volumes of water were currently lost due to leakage and waste. It was estimated that the current consumption could be reduced by 20% if the system was operated in an efficient and businesslike manner.

Ground water was recommended as the most efficient way to meet water shortages. The estimated yield from the Tafuna Plain was 5.5 million gallons per day. When this ground water is combined with surface water, it could easily meet the projected water demands.

The report presented a five year, five million dollar capital improvement program for the fiscal years 1973 through 1977. The program included such items as 1) construction of wells, 2) installation of a 12-inch pipeline from Nuuuli to Fagaalu Village so that ground water could be brought into the Bay Area, 3) increased water storage capacity, 4) treatment facilities for surface water sources, 5) expanded distribution pipelines, and 6) improvements to the existing distribution system and metering of water services to reduce water waste.

6. Preliminary Report-Analysis of Vaipito and Faga'alu Water Treatment Systems, The R.M. Towill Corporation, 1973.

See the following for final report recommendations.

7. Final Report-Analysis of Vaipito and Faga'alu Water Treatment Systems, R. M. Towill Corporation, June 1973.

The purpose of this report was to evaluate the water quality of the existing streams feeding the Vaipito and Fagaalu Reservoirs to determine the adequacy of the present water treatment system to efficiently treat the water and to propose a means of improving finished water quality by rehabilitating the filters. The conclusions and recommendations were that the surface water supplies were not protected and were subject to instantaneous changes in water quality and quantity. These variations in water quality and quantity make the utilization of these water supply systems subject to close scrutiny to see whether they lend themselves to economical and practical management to insure a fail-safe potable water supply. The abandonment, continuation or usage of these systems as a backup should be determined by a master plan evaluation of the water requirements and sources of supply. Consideration should be given to abandoning these sources.

8. Basis for Design - FY 74 Water System Expansion, R.M. Towill Corporation, January 1974.

Prepared to document the basis of the design of the FY 74 water system expansion, this report contains the design criteria, reference reports and design calculations.

It should be noted that the FY 74 construction package was considerably changed by the Government of American Samoa prior to its inclusion as part of the FY 75 improvement program.

9. <u>Analysis of Water Distribution System</u>, The R.M. Towill Corporation, not dated, estimated at January 1975.

This report was prepared prior to the design of the fiscal year 1975 water system improvement program and was a consequence of the previous surface water treatment study which cast serious doubts on the advisability of continuing the use of the existing surface water sources.

The report's stated purpose was to analyze the existing water supply system and to develop recommended improvements necessary to insure that adequate water supply facilities will be available for the design year 1990 in the water service area from the Tafuna well field to Aua.

The report gave the following conclusions and recommendations:

1. The well fields must be capable of delivering 6.9 million gallons per day in 1990 to satisfy water demands.
2. The existing booster stations are undersized to serve the Bay Area if surface water supplies within the Bay Area are not used.
3. Inadequate records are maintained of the water system operating characteristics.
4. No additional storage is required for peak hour equalizing purposes, but fire storage is inadequate in the Tafuna area and marginal in all others not protected by the salt water fire protection system.

10. Standard Specifications and Construction Details for the Water Distribution System, R.M. Towill Corporation, November 1975.

The title of this document is self explanatory of its contents. This document was intended to act as a standard document that would reduce duplication in preparing water system construction documents. The standards were also to provide guidance to government construction and operations forces for their work on the water system.

11. Leak Detection Survey and Personnel Training, Gilbert Associates, Inc., July 1974.

The work undertaken and covered in this report was to perform a leak survey of the government water system.

The survey discovered approximately 500,000 gallons per day in underground leakage and surface service lateral water losses by wastage. Generally the report found the system to be in fair condition, but in need of more efficient operation with a good preventive and corrective maintenance program. The report noted a complete lack of system operating records and construction standards. Metering of all individual services was recommended to eliminate observed water waste.

12. A Report of Immediate Improvements to Water System, Tafuna Plains to Pago Pago Harbor Area, CH2M - Hill, March 1975.

This report was prepared at the request of Governor Earl Ruth in response to continued water shortages in American Samoa caused by record low rainfalls in 1974. This report was used by the Governor at his funding requests in Washington D.C. and contained recommendations for the use of Olovalu Crater for surface water storage and treatment facilities.

Recommendations were made for 1) ground water investigation that would determine the safe sustained yield of the Tafuna-Leone Plain, 2) geotechnical investigations of the Olovalu Crater to determine its suitability for use as a storage reservoir and 3) improvements to the water transmission system that would convey water from Olovalu Crater to the Bay Area without booster pumping stations.

The report should be considered more of a proposal than a planning document.

13. <u>Inventory of the Economic Development Administration Village Water System Program</u>, URS/The Ken R. White Company, October 1975.

This report inventoried the status of the approximately 30 village water systems that were being improved under a grant from the Economic Development Administration. Through brief field visits, interviews with A.S.G. and village officials and reviews of American Samoa Government documents, the report attempted to determine: 1) which village had been completed according to the original program criteria, 2) the present operating condition of the systems and 3) if required, the additional work required to make the system operational.

14. <u>Water System Study: Western Portion of Tutuila Island Including A Proposed South Shore Master Plan</u>, CH2M-Hill, November 1975.

When the A.S.G. proposed to take over the Leone water system in 1974, part of the agreement with the chiefs was that they would have an independent engineer recommend the required improvements.

The first section of this report is in response to that agreement. It analyzes the water system requirements for the area from Amanave to Futiga. Recommendations are based upon domestic, industrial and fire flow requirements projected for the area. The report investigated existing sources and recommended that wells in the Leone Area be used only during the dry season as the supply was limited. The bulk of the water sources were to be from the Asili, Leafu, and Fuafua stream basins. The report recommended distribution and storage facilities.

The second portion of this report was requested by Governor Ruth in response to continued dry weather and acute water shortages in Samoa. A proposal was made for what is called the Olovalu Crater project. The basic features of this proposal were that:

1. The ground water supply on Tutuila Island is finite and may be inadequate to meet total projected water requirements.
2. Existing storage distribution and storage facilities are inadequate to meet existing demands.
3. Misuse and waste of water is a common practice. A universal system of metering should be installed immediately.
4. A large volume (560 million gallons) storage reservoir created within Olovalu crater would eliminate water shortages to the design year 2010 and help to preserve the ground water lens.
5. Surface water supply to the crater would be from the Asili, Leafu and Fuafua streams.
6. All treatment of surface sources would be at a central point at the crater and transmission to the Bay Area would be by high pressure gravity flow in large diameter pipelines.

16. Ground Water Resources of American Samoa with Emphasis on the Tafuna-Leone Plain, Tutuila Island, Bentley C.B., USGS Water Resources Investigation Report No. 29-75, 1975.

This is a summary of the available ground water data for the islands of American Samoa. Includes hydrogeology, descriptions of occurrences of the ground water, the aquifer and well production characteristics and discussions of the future development of ground water. The safe yeild for the Tafuna Plain was estimated at 30,000 acre feet or 26.6 MGD.

17. Public Works Role in Developing American Samoa, Sinagege Randorf Morris, 1976.

Submitted as a part of the requirements for a Master of Public Works Degree, Mr. Morris presents a brief historical background of American Samoa, a review of the Department of Public Works' organizational structure and responsibilities and recommendations for reorganization.

Based upon the author's first hand experience as a management employee in the Department of Public Works for many years, recommendations are given to improve the operational abilities and efficiency of the department.

Recognizing the importance of water to economic growth and health, a recommendation is made for creation of a water and power authority so that the utilities will operate on a businesslike basis separate from the Department of Public Works.

18. The Effect of the Safe Drinking Water Act on American Samoa, Abe Utu Malae, 1976.

Submitted in partial fulfillment of the requirements for a masters degree, this study addresses the costs and benefits that will accrue from implementation of the Safe Drinking Water Act of 1974 as well as Water Quality Monitoring Requirements. It also examines the constraints (administrative, personnel, and legal) that are peculiar to American Samoa and will affect the administration and enforcement of the act.

19. American Samoa's Water System Improvement Program, Mattew J. Flanagan, April 1976.

This paper was prepared for presentation to the 1976 American Water Works Association meeting in Honolulu. The paper contains a short history of Samoa Water System Improvements and explains the basis of the improvement program that is presently underway. The design populations and flow rates that are the basis for the design of current improvement programs are shown.

20. Disinfection of Ground Water Supplies - Predesign Study, CH2MHill, May 13, 1977.

The scope of this study included data collection on operation of existing wells, field analysis of well water to determine chlorine demand, evaluation of alternate chlorination equipment for use in Samoa, and the preparation of a report summarizing the findings.